BYTE

the small systems journal

OCTOBER 1981 Vol. 6, No. 10
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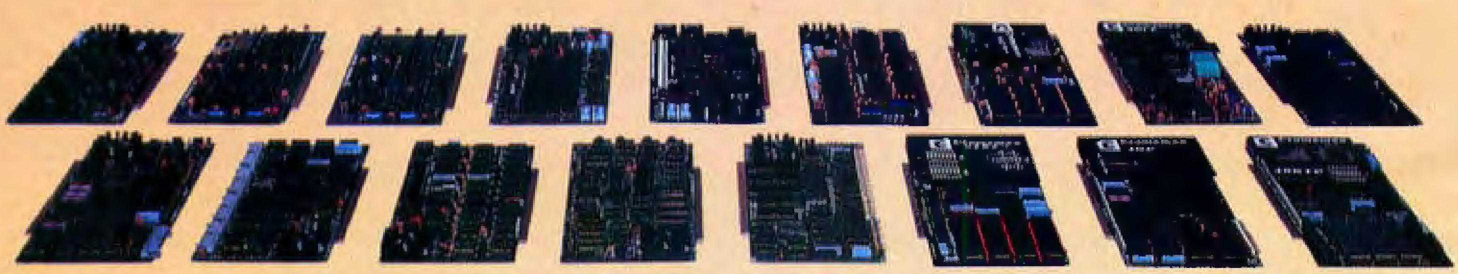


LOCAL NETWORKS

A new small computer that won't limit you tomorrow



New Cromemco System One shown with our high-capability terminal and printer.



Expandability

Here's a low-priced computer that won't run out of memory capacity or expandability halfway through your project.

Typically, computer usage tends to grow, requiring more capability, more memory, more storage. Without a lot of capability and expandability, your computer can be obsolete from the start.

The new System One is a real building-block machine. It has capability and expandability by the carload.

Look at these features:

- **Z80-A processor**
- **64K of RAM**
- **780K of disk storage**
- **CRT and printer interfaces**
- **Eight S-100 card slots, allowing expansion with**
  - **— color graphics**
  - **— additional memory**
  - **— additional interfaces for telecommunications, data acquisition, etc.**
- **Small size**

GENEROUS DISK STORAGE

The 780K of disk storage in the System One Model CS-1 is much greater than what is typically available in small computers. But here, too, you have a choice since a second version, Model CS-1H, has a 5" Winchester drive that gives you **5 megabytes** of disk storage.

MULTI-USER, MULTI-TASKING CAPABILITY

Believe it or not, this new computer even offers multi-user capability when used with our advanced CROMIX* operating system option. Not only does this outstanding O/S support multiple users on this computer but does so with powerful features like multiple directories, file protection and record level lock. CROMIX lets you run multiple jobs as well.

In addition to our highly-acclaimed CROMIX, there is our CDOS*. This is an enhanced CP/M† type system designed for single-user applications. CP/M and a wealth of CP/M-compatible software are also available for the new System One through third-party vendors.

COLOR GRAPHICS/WORD PROCESSING

This small computer even gives you the option of outstanding high-resolution color graphics with our Model SDI interface and two-port RAM cards.

Then there's our tremendously wide range of Cromemco software including packages for word processing, business, and much more, all usable with the new System One.

ANTI-OBSOLESCENCE/LOW-PRICED

As you can see, the new One offers you a lot of performance. It's obviously designed with anti-obsolescence in mind.

What's more, it's priced at only $3,995. That's considerably less than many machines with much less capability. And it's not that much more than many machines that have little or nothing in the way of expandability.

Physically, the One is small — 7" high. And it's all-metal in construction. It's only 14⅛" wide, ideal for desk top use. A rack mount option is also available.

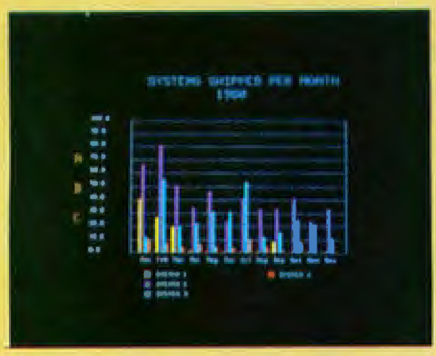
CONTACT YOUR REP NOW

Get all the details on this important building-block computer. Get in touch with your Cromemco rep now. He'll show you how the new System One can grow with your task.

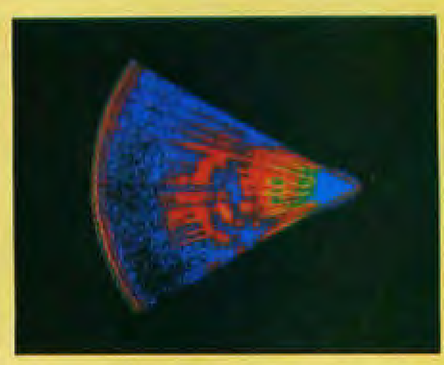
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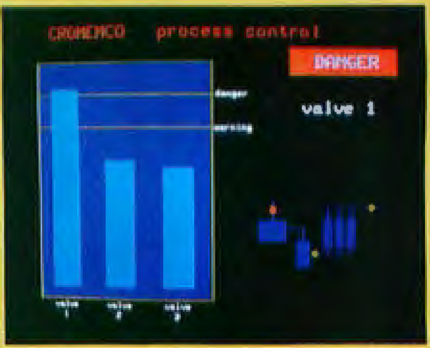
Circle 108 on inquiry card.



Management Information Display



Ultrasonic heart sector scan



Process Control

Get the professional color display that has BASIC/FORTRAN simplicity

LOW-PRICED, TOO

Here's a color display that has everything: professional-level resolution, enormous color range, easy software, NTSC conformance, and low price.

Basically, this new Cromemco Model SDI* is a two-board interface that plugs into any Cromemco computer.

The SDI then maps computer display memory content onto a convenient color monitor to give high-quality, high-resolution displays (756 H x 482 V pixels).

When we say the SDI results in a high-quality professional display, we mean **you can't get higher resolution than this system offers in an** NTSC-conforming display.

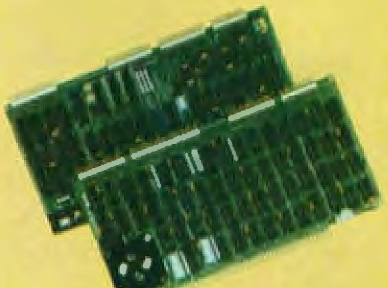
The resolution surpasses that of a color TV picture.

BASIC/FORTRAN programming

Besides its high resolution and low price, the new SDI lets you control with optional Cromemco software packages that use simple BASIC- and FORTRAN-like commands.

Pick any of 16 colors (from a 4096-color palette) with instructions like DEFCLR (c, R, G, B). Or obtain a circle of specified size, location, and color with XCIRC (x, y, r, c).

*U.S. Pat. No. 4121283



Model SDI High-Resolution Color Graphics Interface

HIGH RESOLUTION

The SDI's high resolution gives a professional-quality display that strictly meets NTSC requirements. You get 756 pixels on every visible line of the NTSC standard display of 482 image lines. Vertical line spacing is 1 pixel.

To achieve the high-quality display, a separate output signal is produced for each of the three component colors (red, green, blue). This yields a sharper image than is possible using an NTSC-composite video signal and color TV set. Full image quality is readily realized with our high-quality RGB Monitor or any conventional red/green/blue monitor common in TV work.



Model SDI plugs into Z-2H 11-megabyte hard disk computer or any Cromemco computer

DISPLAY MEMORY

Along with the SDI we also offer an optional fast and novel **two-port** memory that gives independent high-speed access to the computer memory. The two-port memory stores one full display, permitting fast computer operation even during display.

CONTACT YOUR REP NOW

The Model SDI has been used in scientific work, engineering, business, TV, color graphics, and other areas. It's a good example of how Cromemco keeps computers in the field up to date, since it turns any Cromemco computer into an up-to-date color display computer.

The SDI has still more features that you should be informed about. So contact your Cromemco representative now and see all that the SDI will do for you.

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In The Queue

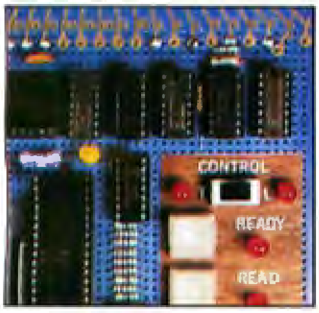
Volume 6, Number 10 October 1981

Features

Reviews

Nucleus

BYTE



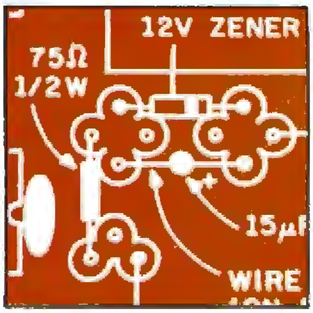
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In This Issue

Local-area networks are a means of sharing information and resources among many personal computers located within a relatively short distance of each other. As Robert Tinney's cover illustrates, each station in the network is linked physically to the others, but each also can operate independently. The local networks themselves need not operate in a void; gateways can link them with other networks thousands of miles away.

To expand on this month's theme, we present an assortment of articles, including "Local-Area Networks: Possibilities for Personal Computers," "Ultra-Low-Cost Network for Personal Computers," and "Network Tools—Ideas for Intelligent Network Software."

In addition, Steve Ciarcia helps you "Build an Intelligent EPROM Programmer," and Martin Hayman discusses "Software Protection in the United Kingdom." We have "The Atari Tutorial, Part 2: Graphics Indirection," and C A Johnson advises on how to "Prepare Your Program for Publication." Of course, you can also enjoy our regular features and much more.

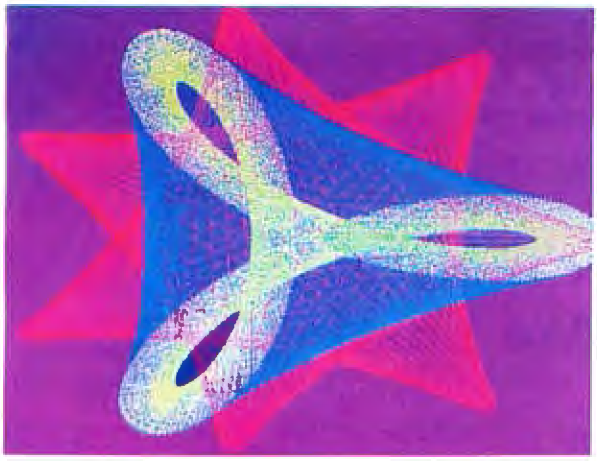
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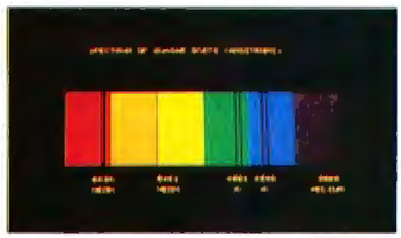
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"...stands well above other S-100 graphics displays in its price and performance range."
BYTE, Product Review

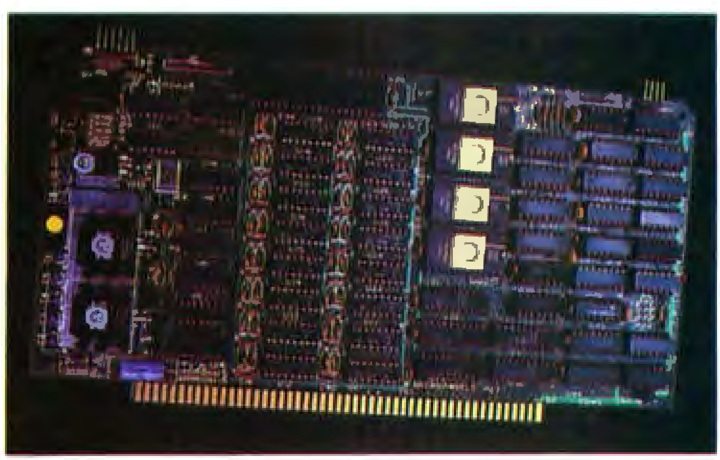


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ELECTRONIC DESIGN, 1981 Technology Forecast

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An optional software superset of Pak I which adds circle generation, polygon flood, programmable split screen for separate graphics and terminal I/O, relative coordinates, faster vector and character plotting, a macro facility, full UCSD Pascal compatibility, and more.

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The new MicroAngelo™ Palette board treats from 2 to 8 MicroAngelos as "bit planes" at a full 512 x 480 resolution. Up to 256 colors may be chosen from 16.8 million through the programmable color lookup table. Overlays, bit plane precedence, fade-in, fade-out, gray levels, blinking bit plane, and a highly visual color editor are standard.

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Editorial

Local Networks Are Buzzing

by Chris Morgan, Editor in Chief

Buzzwords are a way of life in the computer industry, and the latest buzzword (or, to be more correct, buzz-*phrase*) among computer cognoscenti is the *local network*. Networks in one form or another have been with us for some time. IBM's SNA network and the X25 public network from ISO (International Standards Organization), used by Tymenet and Telenet, are systems designed to transmit huge amounts of data over long distances. But recently a whole new industry has sprung up to serve personal computer owners who want to send electronic mail or share the other resources of a local network.

This month we present several articles about local networks, including one written by Harry J Saal, President of Nestar Systems Inc, called "Local-Area Networks: Possibilities for Personal Computers." It's an excellent overview of local networks, their history, and the current state of the art. Much of the impetus behind the blossoming local-network field comes from Ethernet, Xerox's high-end local network system that can transmit up to 10 megabits per second (Mbps) of information between users. You may have seen the recent television advertisements for the Ethernet system.

Although Ethernet works well for large-scale systems employing minicomputers or mainframes, it's a case of overkill for microcomputers, which have inherent speed limitations. Two local network schemes, both patterned in one way or another after Ethernet, now exist to serve the microcomputer market. One such network, made by Nestar, is described in detail by Dr. Saal. The other is a relative newcomer — Corvus's Omninet.

Comparing Two Systems

While the Nestar system, officially called the Cluster/One Model A, is designed exclusively for use with Apple II computers, the Omninet system allows users to mix and match such computers as the Apple II, Radio Shack's TRS-80, the Onyx, and computers using the LSI-11 processor and the S-100 bus.

The data-transfer rate of the Omninet system is 1 Mbps, compared with Nestar's 240 kbps. Although Omninet is technically four times faster than the Nestar system, the numbers can be misleading because the actual amount of time spent transmitting or receiving data to and from the network usually represents only a fraction of the total computing time. Recent tests by Xerox of the Ethernet system bear out these results.

Of more importance to the average user is the network's reliability and how easy it is to use. The Nestar system has been around for more than two years and has earned high marks for reliability and sophistication. It's particularly well suited to classroom use, and I have seen the system at work in many schools around the country. The Omninet system is just beginning to appear on the market, and we plan to review it in detail in a future issue of BYTE. Aside from its ability to handle a variety of computers, Omninet also offers the attraction of low price. The hardware cards for the Apple II, TRS-80, and



New! Z Controller and Z Drives . . .

Expect more from Percom. You won't be disappointed.

Percom's double-density Z Controller for the H-89 is now available.

Check its many outstanding features.

And keep in mind its from Percom, a company that introduced its first disk system in 1977.

• Controls up to four single- or double-headed mini-disk drives. • Handles 35-, 40-, 77- and 80-track drives, and other standard track densities. • Formatted data storage capacity of 80-track diskettes is over 368 Kbytes. Forty-track diskettes store over 184 Kbytes. Capacities for other track densities are proportional. A Z system with four double-headed, 80-track drives provides almost 3 megabytes of on-line data. • The Z Controller co-resides with your H-89 disk drive controller. Your software can select either, and you don't have to move drives around when switching between systems. • The Z Controller includes Percom's proven digital data separator circuit and a dependable write-precompensation circuit. Expect reliable disk operation for a long, long time under 'Z' control. • The Percom Z Controller is priced at only $249.95, complete with HDOS-compatible disk drivers on diskette, internal interconnecting cable and comprehensive users manual.

System requirements – H-89 Computer with 24 Kbytes memory (min), Replacement ROM Kit H-88-7 and HDOS 2.0.

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• Forty- and eighty-track densities in either 1- or 2-drive modules. • All drives are rated for single- and double-density operation. With a Z Controller, an 80-track drive can store over 364 Kbytes (formatted, one-side), a 40-track drive can store over 184 Kbytes. • Some models permit "flippy" storage, letting you flip a diskette and store files on the second side. • Z drives are fully tested, including a 48-hour operating burn-in to prevent shipment of drives with latent defects. • Assembled and tested one-drive units from only $399, two-drive units from only $795.

System requirements – H-89 or H-8 computer with 16-Kbyte RAM, Heath first-drive floppy disk system, HDOS and drives interconnecting cable. (Two-drive interconnecting cable optionally available from Percom)

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S-100-type computers cost less than $500 each, meaning that two interested networkers could assemble a minimal two-node network for less than $1000. The only additional cost is for the twisted-pair wiring used to connect the two computers. No central control computer is needed to run the network.

Data is transmitted on the Omninet in blocks of ASCII characters using software tools called pipes, reminiscent of the pipes used in the UNIX operating system but operating in a different manner. In this way, machines having incompatible operating systems (such as CP/M and UCSD Pascal) can communicate, albeit with some limitations.

Comparing Nestar and Omninet is like comparing the proverbial apples and oranges (pun intended). Omninet is attractive for entry-level users, and it's the only choice if you want to combine various brands of computers. Although rumor has it that Nestar is expressing an interest in other brands of computers besides Apple, the company has made no official statement on the subject.

Nestar has its own advantages, including its excellent track record. The file server used in the Nestar system is actually an Apple II computer, which can act as a spare if needed in the system. Also, Nestar offers extensive and well-documented software. The Nestar system requires 16-conductor ribbon cable for computer interconnection, compared with twisted-pair wire for the Omninet — a cost saving for the Omninet user.

Corvus is actively promoting Omninet as an industry standard for microcomputers. Onyx already has bought an Omninet license, and the Japanese are reportedly interested in the network. (I recently saw a very interesting hobbyist-designed local network system at the offices of *ASCII* magazine in Japan. We hope to tell you about that in a future issue.)

* * *

Siggraph '81

As I write this, the '81 conference of Siggraph (the ACM's special interest group for computer graphics) is in full swing in Dallas, and it's a winner all the way. Ken Livingston (who, with Mark Dahmke, reviewed Siggraph '80 for us last year) is on hand again, and his full report will appear later this year in BYTE. Without trying to steal Ken's thunder, I must say that never before have I seen such exciting portents for the future of computer graphics as I've seen in the last few days at this conference. The demonstrations of the latest computer animation left all previous efforts in their wake.

The roster of attendees includes just about everyone doing meaningful work in the computer graphics field. I wish continued success to Siggraph, and I hope many of our readers can attend Siggraph '82, to be held in Boston next summer. For more information, write to Elaine Sonderegger, Siggraph '82 General Chairman, at POB 353, Derby CT 06418. ■



The ultimate single user machine

The PDS-80™ with Cache BIOS™ is a professional system designed for the most rigorous single user CP/M* environments ... in business, software development, scientific, educational and industrial research ... where speed and program space are critical factors.

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No matter what high-level language you use ... Cobol, Basic, Fortran, PL/1, or Pascal ... PDS-80 offers more speed, power and reliability than any other floppy based CP/M system currently on the market. The InterSystems Cache BIOS fully exploits the advanced DMA and interrupt features of our reliable Series II hardware to buffer whole tracks in extended memory so most operations run two to four times faster than on other floppy based systems ... actually equals the speed of many small hard disk systems. And Cache BIOS also provides many sophisticated system test and protection features to assure reliable operation.

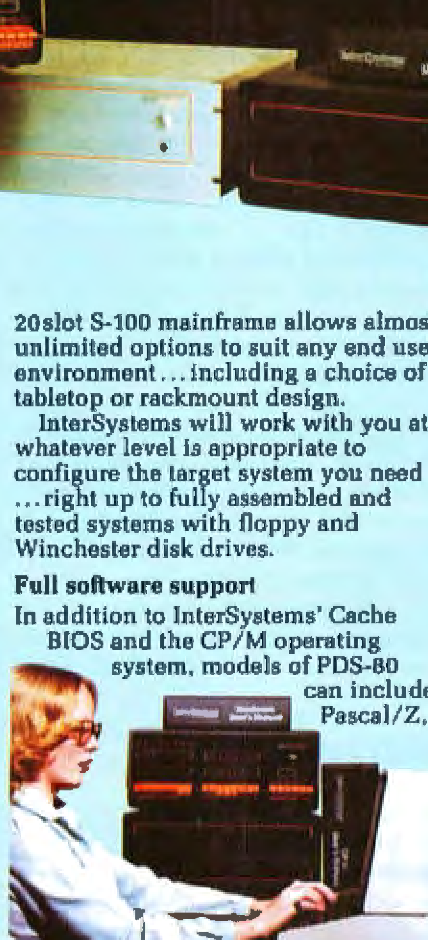
An advanced CP/M application system

PDS-80 has all you need for commercial systems integration and applications software development ... including a choice of the industry's only integral 8 bit front panel. Best of all, PDS-80 allows the systems integrator or applications developer addressing a vertical market to develop on the same components he configures for resale. The highly expandable modular design with 20slot S-100 mainframe allows almost unlimited options to suit any end use environment ... including a choice of tabletop or rackmount design.

InterSystems will work with you at whatever level is appropriate to configure the target system you need ... right up to fully assembled and tested systems with floppy and Winchester disk drives.

Full software support

In addition to InterSystems' Cache BIOS and the CP/M operating system, models of PDS-80 can include Pascal/Z,



our highly acclaimed Z-80® native code Pascal compiler, and InterPak 80™, a special set of utilities including a powerful screen editor and versatile spelling editor to assist in the rapid editing, proofing and documentation of your code. These powerful programming aids are also available as standalone products.

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Both hardware and software are designed to provide for upgrade to 16 bit operation. Programs written for Pascal/Z are fully compatible with I-Pas 8000™, our Z-8000® native code compiler, and all PDS-80 systems are upgradeable to our 16 bit multi-user DPS-8000.

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Letters

Clearing Waveforms

I enjoyed reading Robin Moore's article "Mountain Computer's MusicSystem" (July 1981 BYTE, page 60). There may be some confusion, however, about the way the Casheab synthesizer handles waveform storage. With the Casheab synthesizer, waveforms are stored on the synthesizer cards and not in the host memory. This was done for three reasons:

- The Casheab synthesizer uses 1024 words by 12 bits for each of its 16 waveforms. This requires 25 K bytes of memory, which would be a considerable chunk of memory space if the waveforms were stored in the host's memory space.
- When the waveforms are stored in the host's memory, processor time is going to be required to transfer them to the synthesizer. The MusicSystem uses DMA (direct memory access), which is probably the most efficient way to make the transfer. However, this effectively slows the Apple's processor from 1 MHz to 500 kHz.
- It is much easier to add more channels to a system by adding another synthesizer card set when the waveform tables are not in the host memory.

Ceasar Castro
Casheab
5737 Avenida Sanchez
San Diego CA 92124

Unsung Marketer

While I thoroughly enjoyed the recent article entitled "The Japanese Computer Invasion," I would like to go on the record to correct some misleading information that appeared in the section regarding Hitachi on page 212, beginning with the third paragraph. (See the August 1981 BYTE.)

Mr Miastkowski is correct in stating that there is no Hitachi marketing organization in the US (for large-scale computers, that is, a qualification that should have been included) nor any movement toward developing one. However, to call this a "major problem" totally ignores Hitachi's satisfaction with the job being done by National Advanced Systems (NAS). "Lack of a US organization" has *not* "hurt" sales of the AS/9000. Indeed, NAS has doubled the sales rate of its predecessor and is progressing very well in AS/9000 penetration.

Mr Miastkowski also states that Hitachi introduced the AS/9000. This is incorrect. NAS introduced the AS/9000, its redesign of the Hitachi M200H.

It is also incorrect to characterize NAS as a company "with (merely) a large amount of small-computer experience." In the 303X class and upward, NAS has 276 systems installed, hardly a lack of experience. If one includes MVS-class machines (which are generally considered not to be "small" systems), the number goes to about 600! And, in the "H" class, the subject of the paragraph, we have more experience than either IBM or Amdahl (i.e., we're shipping and they aren't)!

Lastly, Miastkowski refers to the "strange bug" which occurred at Lockheed Dialog and implies that service is a major problem. This is absolutely untrue. Specifically, a problem arose in the channel check logic in which the software was unable to recover from a channel check. Investigation revealed that, while the AS/9000 channel interfaces were designed to published IBM specification documents, IBM had subsequently changed (in this case, loosened) the parameters governing the timing of the counting of parallel bits. We immediately applied an EC retiming the parameters and retrofitted all other AS/9000s. The incident, in fact, illustrated the expertise of our engineers in solving a problem we did not even create and in solving it in record time.

David Goldsmith
Director—Sales Support
National Advanced Systems
800 E Middlefield Rd,
Mountain View CA 94043

On Old Ad Age

As a mechanical engineer, I have had BYTE save my neck by letting me know what to expect from the "Silicon Wonders" before other engineers. But I would like to share some observations about BYTE that I have made over the last five years.

BYTE has evolved from a magazine of "hobbyists" into a leading and respected technical journal. As such, the reader is assumed to have sufficient technical expertise to read and assimilate the information presented. To my knowledge, this assumption has turned off a number of potential subscribers. It shouldn't be too difficult to publish a yearly "Beginner's Intro" issue of BYTE which could be included with every new subscription. It could educate and entice new subscribers, while the "old-timers" shouldn't object too strenuously to a yearly review of basics (who knows, it might even help). It would definitely help overcome the shock to a neophyte who wants to learn about the nitty-gritty of computers and picks up a BYTE only to be deluged with "computerese" and articles that go over his or her head in the first paragraph.

A good portion of each BYTE is devoted to advertisement. I am not complaining. In fact, I have learned almost as much about computers from the ads as from the articles. But I currently have about 30 inches of bookshelf devoted to BYTE and, if the advertisements could be removed, that could be cut down to 20 inches or less! An advertisement that's a year or more old is of little value to me, but articles that age are very valuable to me. What I suggest is to bind the articles in one group that can be removed for filing. They could be preceded by the "prestige" ads and followed by the bulk ads. I doubt that this change in format would reduce the effect of advertising in BYTE since most of BYTE readers that I know either read every ad in each issue or ignore them. It would reduce the space required to archive back issues considerably. (I'd like to see this idea catch on because I currently have over 15 feet of bookshelf dedicated to my technical journals and it's growing daily!)

Lew Merrick
19217-28th Ave W
Lynnwood WA 98036

Our "potential subscribers" who are turned off by our technical level should take a look at our new sister publication, Popular Computing. . . . MH

Legal Arguments

As an attorney, computer enthusiast, and coauthor of a recently published booklet entitled "The Copyright Kit—How to Copyright Your Computer Software," I feel I must clarify two points raised by Stephen Becker in his article

A Busload from SSM.



80 Character Video

With 80 characters per line our VB3 is the perfect video interface for word processing. It produces a standard 80x24 display of upper and lower case characters or as much as 80x50 for a full page of text. The matrix for graphic display goes up to 160x200. And with optional EPROM, as many as 256 user programmed characters or symbols can be produced.

VB3 is memory mapped for rapid screen updating. But it occupies memory only when activated. So one or more VB3s can be located at the same address with a full 65K of memory still available to the user.

It generates both U.S. and European TV rates and meets IEEE 696.1 standard. Other features include keyboard input, black on white or white on black, one level of grey, underline, strike thru, blinking char., blank-out char., and programmable cursor. Software includes a CP/M compatible driver and a powerful terminal simulator.

Z-80 CPU

We spent over a year designing the CB2 to assure that it is the most fully S-100 compatible Z-80 CPU on the market.

It operates at 2MHz or 4MHz by DIP switch selection and includes two sockets for 2716/2732 EPROMs or 2K RAMs. Memory sockets can be disabled. Separate run/stop and single step switches allow system evaluation without the benefit of a front panel.

CB2 also features an MWRITE signal, firmware vector jump, and an output port to control 8 extended address lines (allowing use of more than 65K of memory). Jumper options generate the new IEEE 696.1 signals.

8080 CPU

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"Legal Protection for Computer Hardware and Software." (See the May 1981 BYTE, page 140.)

Mr Becker tells us that he does not recommend that his clients copyright (i.e., register) their software until an infringement suit is contemplated. My advice would be just the opposite.

Section 412 of the 1976 Copyright Act specifically disallows statutory damages and attorneys' fees for any infringement of copyright commenced after first publication of the computer program if it was not registered within three months after the first publication of the work. This means that by not registering a computer program within three months of publication, you lose possibly important damages for infringement. For $10 (the cost of registration), I feel a computer program should be registered at the earliest possible moment.

Mr Becker also states that two copies of a computer program must be filed with the Copyright Office along with form TX for registration. In fact, the Rules and Regulations of the Copyright Office (Section 202.20 (c) (2) (vii) Code of Federal Regulations) provide that for a computer program published only in the form of machine-readable copies (such as magnetic tape, disk, punch card, or the like) from which the work cannot ordinarily be perceived except with the aid of a machine, the deposit need only consist of one copy of the first and last 25 pages of the program printout together with the page where the copyright notice appears.

I hope these corrections, in part, clarify for BYTE readers a complex area of the law.

Noel D Adler
14 Longacre Ct
Port Jefferson NY 11777

Stephen Becker Replies

I stand by my advice. Mr Adler's statement that "Section 412 of the 1976 Copyright Act specifically disallows statutory damages and attorneys' fees for any infringement . . ." tells only part of the story. In fact, the 1976 Copyright Act specifically provides for statutory infringement occurring after registration, *whether or not registration occurs within three months after first publication of the work.*

Ideally, each program should be registered as soon as possible. Copyright registration of a program is neither as complex nor expensive as patenting. It can, however, be burdensome to register each program, particularly if you are developing a substantial amount of new software. Each registration requires, besides the $10 registration fee and attorney's fees (if one is retained), deposit of a copy of the first and last 25 pages of the program printout together with the page where the copyright notice appears if the program is published only in machine-readable form, *as Mr Adler notes; otherwise, two complete copies of the program must be deposited.*

As a practical matter, however, the software supplier will probably become aware of any infringement fairly soon after it occurs. The infringer will be liable for statutory damages and attorneys' fees for all infringements following registration. If the registration occurs within three months from the first publication date, the infringer will be liable even during the three-month intervening time period. Even before registration, the courts have the discretion to allow recovery of the infringer's profits to the software developer and may even require that royalties be paid.

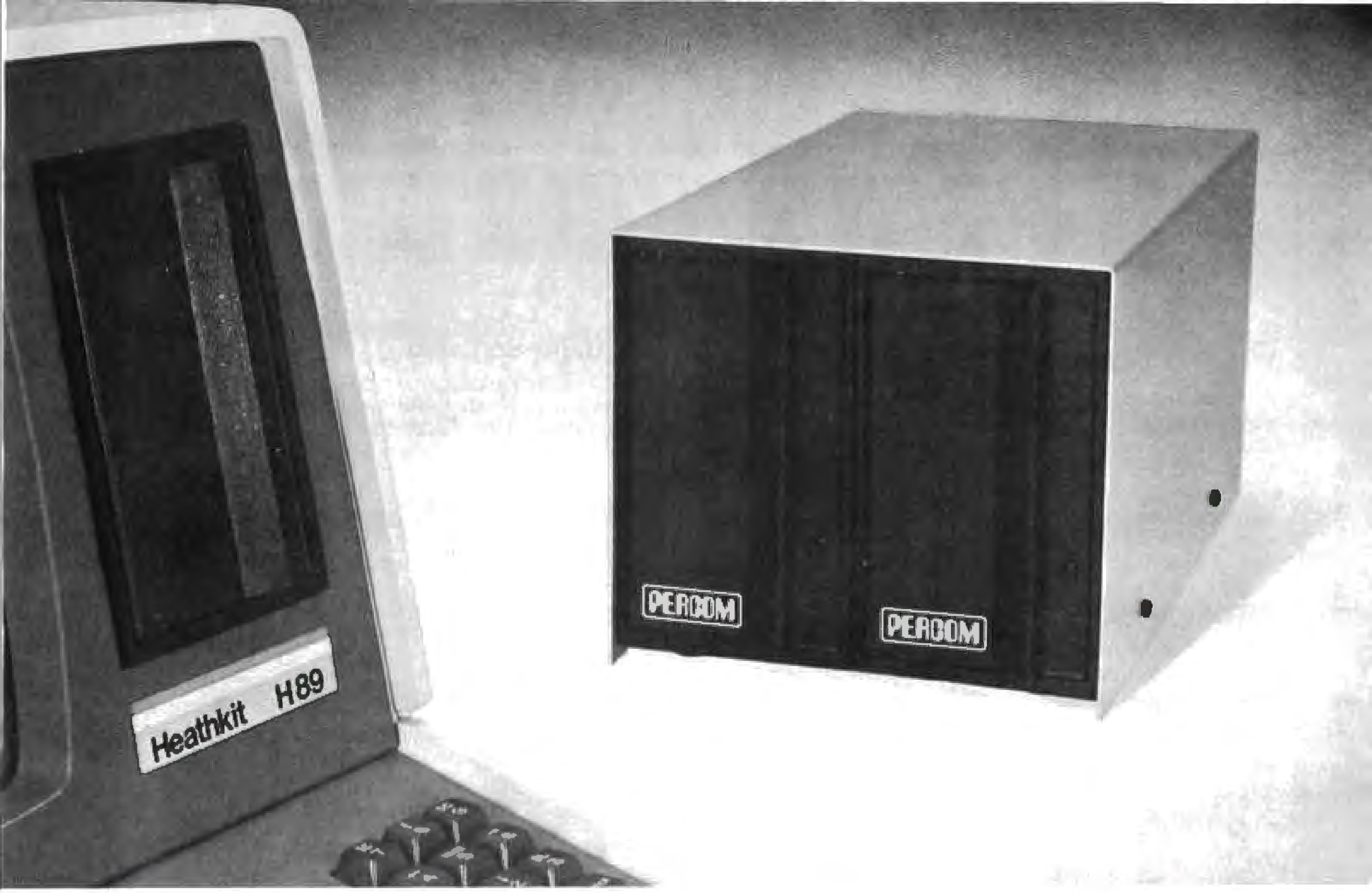
BYTE's Guide Praised

My wife and I wish to thank BYTE for including Mister McGiddies Creations Ltd in "The BYTE Guide: NCC Chicago." (See the April 1981 BYTE, page 64.) It is nice to be recognized for all the work we have done to promote the best in Bluegrass music in Chicago, while serving high-quality food at a good price.

McGiddies is now computerized by a 48 K-byte Radio Shack TRS-80 Model I with multiple disk drives, Scripsit, and the Paper Tiger 460 printer. Without a publication like BYTE, the information that I would need to learn how to use a computer in small business would not be available. I can actually say the computer has put some fun back into paperwork, and, of course, the games are always fun.

Thank you, BYTE. Keep up the good work.

Hal and Sharon Berger
President and Vice President
Mister McGiddies Creations Ltd
2423 N Lincoln Ave
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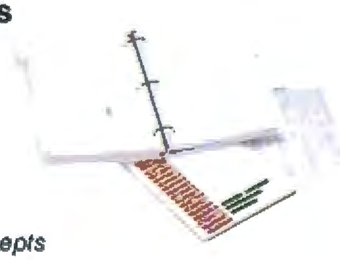


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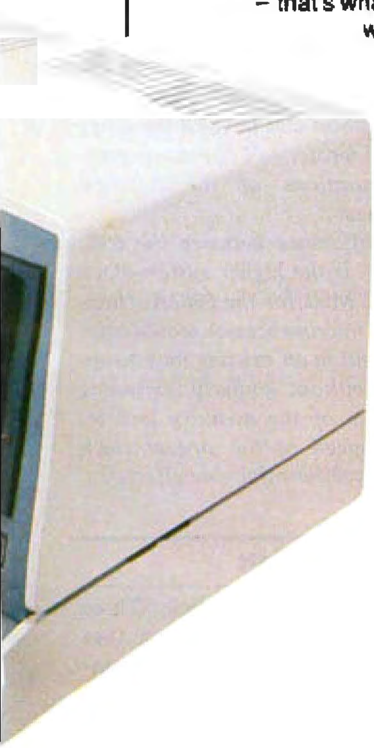


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Comments on VIC

I recently evaluated the specifications of various personal microcomputers now on the market, so I noticed a couple of errors in Gregg Williams's comparison of Commodore's new VIC 20 to other microcomputers. (See "The Commodore VIC 20 Microcomputer," May 1981 BYTE, page 46.)

Mr Williams stated that the VIC is the only machine in which "the background color can change independently of the character color." This is untrue. If the Atari is used in graphics mode 1 or 17, its normal text display is reduced to 24 rows by 20 columns (similar to the VIC's 23 rows by 22 columns) and the background color becomes separately adjustable to any of 16 colors. Mr Williams also incorrectly stated that the Atari's normal text display is "16 rows by 32 columns"; actually it is 24 rows by 40 columns, which means it can display 25% more text than any of the other computers he surveyed. It also can be expanded to a full 32 K bytes of memory by installing one of the new 32 K-byte "RamCram" boards made by Axlon (Sunnyvale, California).

On the whole, BYTE should make more of an effort in the future to standardize comparison tables. For example, the cost of each system with a fully extended BASIC in ROM (read-only memory) and 16 K of programmable memory could be given. The graphics capabilities should be compared in some way to show the trade-off between high-resolution and multicolor capabilities, such as the maximum resolution available if you want the ability to display four colors simultaneously with individual color control over each pixel. I would be interested to know how the VIC with the Super Expander Cartridge would compare with the other machines reviewed according to this criterion. If the advertised 176 by 176 pixels are individually assignable to any of four (or more) colors, then the graphics capabilities of the VIC 20 would lie between those of the Apple (280 by 192) and the Atari (160 by 96), being approximately equivalent to the Radio Shack Color Computer (128 by 192).

Finally, Mr Williams mentioned that the VIC 20 uses the 6502A microprocessor instead of the 6502. What's the difference? Also, is it possible to replace the 6502 with a 6502A?

George Fergus
1810 Hemlock Pl #204
Schaumburg IL 60195

Gregg Williams Replies

Mr Fergus's two points about the Atari are correct—my apologies for the errors. His comments on the fairness of the comparison chart point up the difficulty of comparing several microcomputers fully. Anyone buying a microcomputer should learn everything he or she can about the different brands (just as Mr Fergus did). Such an evaluation was beyond the scope of the article I wrote, so I chose representative configurations of the different microcomputers.

The only difference between the 6502 and the 6502A is the higher system-clock frequency of 2 MHz for the 6502A. However, a 6502A microprocessor would offer no improvement in an existing microcomputer system without similarly upgrading the access time of the memory and increasing the speed of the system clock (which may have harmful side effects).

APL Pals

I read Gregg Williams's article "Three Versions of APL" with great interest. (See the April 1981 BYTE, page 188.) His conclusion that Vanguard APL/V80 is the fullest and fastest implementation is one that we agreed with two years ago when

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I hope BYTE will include us in its next language review. There are some exciting projects in the pipeline for 16-bit APL systems. APL is very popular in Europe, so in the meantime, we hope European readers will feel free to contact us if they're interested in further details.

Robert Bittlestone
MicroAPL Ltd
19 Catherine Pl
Victoria, London, SW1E 6DX, England

Roots Fair and Square

Steve Able's statement that any 10-digit calculator that accurately yields $(\sqrt{2})^2 = 2$ ". . . is either doing "funny arithmetic" or else is not telling you everything it knows" aroused my curiosity. (See "Letters," April 1981 BYTE, page 16.) My rather ancient Texas Instruments SR-51A does, in fact, yield $(\sqrt{2})^2 = 2$. So I wondered if it was performing "funny arithmetic" or was hiding information from me.

The SR-51A does calculate $\sqrt{2}$ to 13-digit accuracy as does HP-41C, then displays the result rounded to 10 digits. The difference is that the SR-51A does not then proceed to forget the additional three digits. These are still retained in the register and are used in any subsequent operations.

The $\sqrt{2}$ operation produces a displayed result of 1.414213562, but the internal memory has 1.414213562373. Squaring correctly produces a rounded result of 2. The other functions also produce 13-digit accuracy rounded to 10 digits for the display.

In the words of Mr Abel, my SR-51A "is not telling me everything it knows." But, why should the accuracy of the machine be limited to the size of the display? Because it does not forget the extra three digits it calculated, the outdated, middle-line SR-51A performs with greater accuracy than the new, top-line, very expensive HP-41C.

In addition, my SR-51A, with a little trickery, will tell me "everything it knows." Entering $\sqrt{2}$ yields a display of 1.414213562. First, I multiply this by 100, which produces 141.4213562; then I subtract 141, producing a display of 0.4213562373. There are the three extra digits.

For π, the displayed result is 3.141592654. Multiply this by 100, then subtract 314, and the result 0.159265359 is displayed. This would be accurate for the 14-digit value of π = 3.1415926535897 rounded to 13 digits. The trailing 0 is suppressed in the LED (light-emitting-diode) display to conserve the batteries.

It is also possible to enter 13 digits with an appropriate trick. To enter 1.414213562373, first enter 3.73 EE-10, then add 1.414213562. This will result in the register containing 1.414213562373, and squaring this will produce the rounded answer of 2.

Apparently, this accuracy cannot be achieved with "the world's fanciest calculator."

James E Kitchen
Director
Chapman College
Residence Education Center
General Delivery
Beale AFB CA 95903

Talking DVMs

In Steve Ciarcia's "Build a Low-Cost Speech-Synthesizer Interface" (June 1981 BYTE, page 46), he describes an encounter with a disbelieving clerk "at a local electronics store" after asking if they carried "any DVMs (digital volt ohmmeters) that talked." Steve implies that today none exist, but someday they will be very common. Well, at least one does exist.

I recently came across a reference to a "talking DVM" in the March 1981 *Journal of Chemical Education* (page 231). It's available from Sabtronics International Inc, 13426 Floyd Cr, Dallas TX 75243 (product number DMM 2010A).

Charles J Spillner
4054 Shona Ct
San Jose CA 95124

The Franklin Institute Research Laboratory also has a talking voltmeter available. Contact the company at Benjamin Franklin Pky, Philadelphia PA 19103, (215) 448-1340. . . .



BDS C Update

Thank you, BYTE, for the "printf" technical note and the larger article on BDS C, by Chris Kern. (See "Printf for the C Function Library," May 1981 BYTE page 430, and "The BDS C Compiler," June 1981 BYTE, page 356.) Unfortunately, the items have fallen victim to some time-warp distortion, and several points regarding the package were out of date.

In the printf article, reference is made to a clumsy method of passing formal parameters to C functions in which the parameters are copied into absolute locations in memory by the caller and accessed from there by the subordinate function. The parameter-passing mechanism of BDS C has been totally revamped since those days. Currently, all parameters are passed on the stack, and all local (automatic) variables also reside on the stack. Also, a printf that is functionally equivalent to Chris Kern's is now a standard part of the package.

The June review was completely accurate in all technical details, except for the statement that "it's a shame the BDS compiler doesn't go one step further and provide redirected input and output. . . ." Actually, the current version of BDS C does include a special-function library for performing both directed I/O (input/output) and *pipes* in the standard UNIX-like manner. This is a recent addition to the package, and it has the advantage of not wasting any memory if it isn't used, because it's merely a simple set of library functions (written in C, of course).

BDS C users may be interested to know that the compiler has recently been run under the MARC operating system (a UNIX-like system) and that the combined package will be available soon from Vortex Technology. MARC furthers BD Software's tradition of translating the "best" of UNIX onto 8080- and Z80-based systems. BDS C finally has an operating system it can appreciate, rather than battle.

Leor Zolman
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Points on Printers

In connection with the review "The Epson MX-80 and MX-70 Printers" (see the May 1981 BYTE, page 22), the following specific comments may be of interest:

- The MX-80 offers four rather than three character densities. The fourth is the double-width reduced character. It is produced by an SO (shift-out) code when an SI (shift-in) code is in effect. The resulting density is 3.25 characters per cm (8¼ per inch).
- A fourth character style can be obtained by transmitting codes for both boldface and emphasized. The result is a character heavier in both horizontal and vertical lines.
- Line spacings of less than ⅙ of an inch on the MX-80 are overridden when graphic characters are present. In our experience, even a single graphic character in a line will cause the line feed to default to ⅙ of an inch. (This phenomenon is not covered in the user's manual.)
- The annoying buzzer on the MX-80 can be turned off by use of internal switch 1-6.
- The MX-70 (even though its character matrix is 5 by 7) produces a graphic matrix of 480 by 8 pixels per line.

As for the Apple II interface, which does not transmit the high bit and, hence, the graphic characters, the peculiarity lies in the Epson-designed interface, rather than the Apple's memory. Our company produces and distributes an interface for the Apple II and the Epson printers that transmits all bits and all characters. We also produce a firmware printer-support card for the Apple II. In conjunction with our interface, this card will (in addition to many other functions) produce a low-resolution graphic dump on the MX-80 using the graphic characters and a high-resolution graphic dump on the MX-70, which is printed as eight graphic lines on each pass.

Amnon Katz
President
Inverted—A Inc
401 Forrest Hill Ln
Grand Prairie TX 75051

I have just purchased the MX-70 version of Epson's printer, and I would like to make two comments on the May 1981 BYTE article.

First, the MX-70 can print with eight points, not seven, which means that with special software it is possible to print lowercase descenders by utilizing the graphics mode.

Second, the Epson interface card for the Apple II computer has a link option for the most-significant bit that must be changed to allow this bit to get to the printer. The graphics mode requires a true 16-bit (2-byte) argument to instruct the printer as to how many bytes are to be interpreted as points on the print head. Also, a complete byte is required to define which print hammer is to strike. Before I discovered this, I had some weird effects every time I tried the graphics mode.

I think the graphics mode is the most significant part of the MX-70 because it allows a large number of extra features to be defined by the user:

- special-character sets
- proportional spaces between characters
- proportional spaces between words
- overstrike, and
- underlining

Bruce Piggott
725 Flower City Pk
Rochester NY 14615

Changing Names

Gary Stotts's Apple Name-Address program is so useful that I made a modification for my own purpose. (See the April 1981 BYTE, page 32.) Although there is a way to change the address and telephone number of a person listed on the file, there is no way of changing a person's name. There may be reason to change the person's name: marriage, for example. I have added a few lines to the program to do just that. (See listing 1).

Gino J Piazza
49 Browndale Pl
Port Chester NY 10573

Listing 1

```
1172  PRINT : PRINT "OLD: ";N$(I)
1175  PRINT : INPUT "NEW: ";N$(I)
1177  IF LEN (N$(I)) < 1 THEN 1175
```

■

Credit Due

We inadvertently omitted the credit line for the photographer responsible for the photographs in "A Look at NCC '81" (September 1981 BYTE). We apologize to Richard Faverty.

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The IBM Personal Computer
First Impressions

Phil Lemmons
89 Remsen St
Brooklyn NY 11201

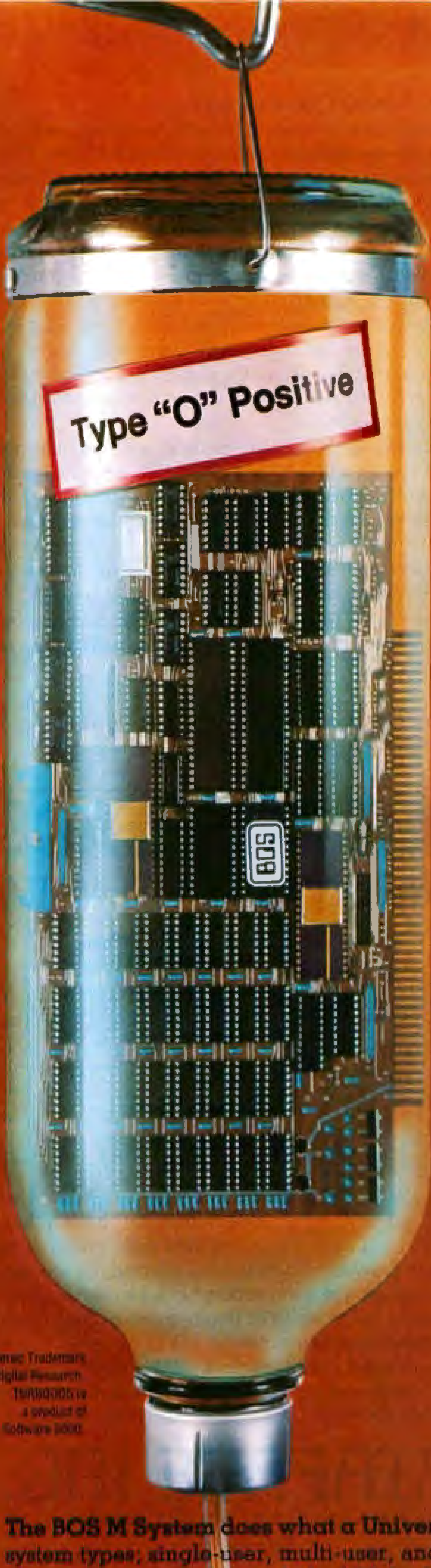
IBM (International Business Machines Corporation) has at last introduced the keenly anticipated IBM Personal Computer. Based on Intel Corporation's 8088 microprocessor, the new machine is slated to appear in stores this month, with various hardware options, at prices ranging from $1565 to more than $5000. Color graphics are built in, and up to 256 K bytes of user memory may be installed.

The hardware is impressive, but even more striking are two decisions made by IBM: to use outside software suppliers already established in the microcomputer industry, and to provide information and assistance to independent, small-scale software writers and manufacturers of peripheral devices.

The list of software sources includes Microsoft, Digital Research, Personal Software, Peachtree Software, Softech Microsystems, and Information Unlimited Software. For hardware configurations including floppy-disk



Photo 1: *The new IBM Personal Computer is based on the Intel 8088 microprocessor and will be supported by software from well-known, independent sources. Shown here are the System Unit with two built-in 5-inch floppy-disk drives, the black-and-white video monitor, the adjustable keyboard, and an Epson MX-80 printer bearing the IBM label, all of which sells for $4385.*



See us at Comdex '81 in Las Vegas, Booth #774.

The BOS M System: The Universal Donor

The BOS M Card is the heart of the M System. It is designed to be IEEE S-100 bus compatible for universal system use. Virtually all elements of a computer mainframe now reside on one S-100 card — Z-80A CPU, 64k of 200ns RAM (no wait states), 4k 250ns EPROM, Winchester Disk I/O port, two RS-232 serial ports, system port, floating point processor, and parallel I/O. The same M Card can be used in single-user, multi-user, or even multi-processor systems.

Second Generation Multi-Processor. With the BOS M Card, multi-processing is finally free of the Master/Slave and hand-shaking parameters so prevalent in first generation multiprocessors. Inter-system communications are FIFO buffered; the old "Master" is now a slave to the user, and the system functions without "S-100 bus overrun" or system generated wait states.

The Universal Processor is now a reality! As a single-user system, the BOS M is unmatched in performance (up to ten times the speed of other microcomputers). As a multi-user system, this power can be translated into a low cost multi-terminal capability. As a multi-processor, the system leaves the realm of "microcomputer" and competes in performance with a minicomputer! You can start with a single-user computer and expand to a multi-user/multi-processor computer system when needed.



The Universal Product. BOS has what you need — anything from a single M Card to a complete turnkey computer system. Diskette, rigid disk, tape and telecommunications sub-systems are all available. Compatible software includes CP/M*, MP/M*, CP/NET*, BOS/TURBODOS, complete monitor, languages, application packages, and more!

Dealer and OEM Inquiries Welcome

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Business Operating Systems, Inc.
2835 East Platte Avenue
Colorado Springs, Colorado 80909
In Colorado Call: (303) 634-1541
Toll Free Number: 1-800-525-3898

Circle 49 on inquiry card.

The BOS M System does what a Universal Donor must do — it provides high performance for all system types; single-user, multi-user, and multi-processor. M Systems start at less than $5,000.00 for a single-user computer with dual 8" double density diskette drives.

drives, IBM will sell three different disk operating systems: CP/M-86 from Digital Research, the UCSD p-System from Softech Microsystems, and IBM Personal Computer DOS, developed by Microsoft in imitation of CP/M. IBM isn't trying to force the world to choose between the IBM DOS and other popular operating systems. The published documentation of IBM Personal Computer DOS will include the source-code listing of the BIOS (basic input/output system), and of the diagnostic programs executed automatically when the computer is turned on.

The hardware uses an interconnection scheme different from the industry-standard S-100 bus, but IBM doesn't want to exclude anyone from developing plug-compatible printed-circuit boards for installation in any of the vacant expansion slots inside the chassis. In fact, the company plans to publish a hardware manual with drawings and industry-standard specifications. IBM's attitude toward support for independent hardware and software efforts was summarized by Don Estridge, Director of Entry Systems Business for the IBM Personal Computer. "IBM will provide information for the existing cottage industry to design boards," Estridge said. "We're open to any software proposals."

General System Characteristics

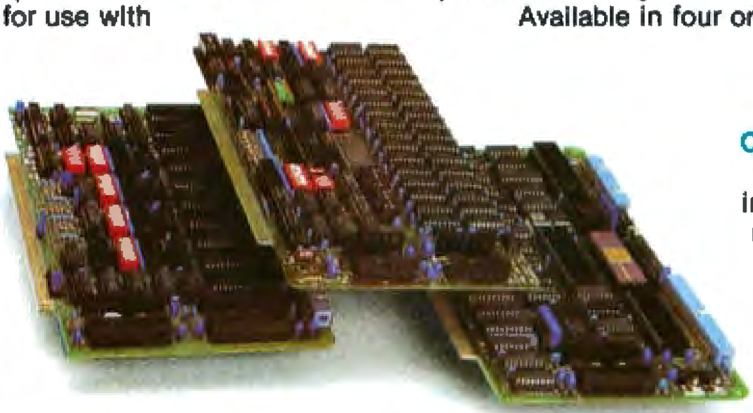
The entry-level version of the IBM Personal Computer consists of the System Unit, which contains the 8088 microprocessor, a 40 K-byte built-in ROM (read-only memory) containing the extended version of Microsoft BASIC, a built-in speaker that can be programmed to play music, a power-on automatic self-test of system components, 16 K bytes of user memory in the form of semiconductor RAM (random-access read/write memory), a combination video-monitor and printer adapter, and empty space for two 5-inch floppy-disk drives. In this minimal configuration, the system uses an audio-cassette recorder for mass storage and an ordinary television set as a video monitor.

Not including the cassette recorder and monitor, the minimal system will sell for $1565. With a single 5-inch, 160 K-byte floppy-disk drive and 64 K bytes of user RAM, the price increases to $3005. An expanded business system with powerful color graphics, two floppy-disk drives, and an IBM-labeled Epson MX-80 dot-matrix printer costs $4500. In addition to the 40 K-byte ROM, the system has a 16 K-byte RAM buffer for graphics operations. None of the user memory is required by the system software.



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DOUBLE DENSITY FLOPPY DISK CONTROLLER BOARD— controls up to four 5¼-inch or 8-inch disk drives using IBM soft sectored formats. It features 1K of on-board buffering, DMA controlled data transfers and the performance characteristics of the superior NEC 765 chip.

64K BANK SELECTABLE MEMORY BOARD — Features include I/O port addressing for bank select with 256 switch selectable I/O ports for the memory bank addressing. The memory is configured as four totally independent 16K software-selectable banks, with each bank addressable on any 16K boundary.

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Plug-in circuit cards of user RAM are available in three denominations: 16 K bytes ($90), 32 K bytes ($325), and 64 K bytes ($540). The user can increase the memory capacity to 256 K bytes using the available IBM boards and slots. (Outside companies could make a single memory board containing 256 K bytes of RAM, or expansion boards that contain even more.) All user memory is 9-bit, with one bit devoted to parity check. An edge connector on the back of the System Unit looks as if it is longing for a hard-disk drive, but IBM is mum on that possibility.

The 8088 processor communicates with memory and peripheral devices through an 8-bit data bus, but it conducts its internal affairs using the 16-bit instruction set of Intel's 8086 microprocessor. In the IBM Personal Computer, the 8088 operates at 4.77 MHz, with a cycle time for main storage of 410 nanoseconds; for access, the cycle time is 250 nanoseconds.

Together, the System Unit, keyboard, and a monitor make a very smart, full-feature terminal. A six-foot coiled cable connects the separate keyboard to the System Unit. You can adjust the keyboard's tilt toward you when it rests on a desktop, or you can hold it in your lap. The system supports both uppercase and lowercase characters, and all 83 keys have automatic repeat. Ten keys on the right side are for a numeric keypad and cursor controls, and ten special-function keys can be used for editing. The keyboard provides access to 256 characters, including all the ASCII (American Standard Code for Information Interchange) characters and many other characters useful for producing virtually any sort of graphics display.

IBM sells an 11½-inch green-phosphor video monitor for $345. The monitor displays 25 lines of 80 characters each. You can adjust brightness and contrast or use soft-

SYSTEM 2800

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As a family of expandable microcomputers intended for single and multi-user applications based on CP/M*, MP/M* and OASIS**, the SYSTEM 2800 contains many big system features. Outstanding characteristics such as FAST operation make it a clear market leader. In fact, the SYSTEM 2800 is one of the fastest Z80-based systems recently benchmarked by Interface Age magazine.

*CP/M and MP/M are Registered Trademarks of Digital Research.

**OASIS is a Trademark of Phase One System, Inc.



Other features include the capability to BOOT from any drive including the hard disk, and extensive error recovery. The error recovery prompts the user with detailed error messages and prevents system lock up, all too common to many other systems.

Designed for easy service, the SYSTEM 2800 comes with two 8-inch drives: a choice of single or double sided, double density floppies with up to 2.52 MBytes of formatted storage; 10 or 20 MByte Winchester hard disk; and 20 MByte tape drive for disk backup.

These enhanced features result in a highly reliable, quality built, state-of-the-art microcomputer that gives you the cost/performance edge you need to be a leader in your field.

Dealers, OEM's and System Integrators share many common needs. Not the least of these is dependable products. That's why we back our SYSTEM 2800 with our established reputation for high quality, superior support, prompt and courteous service, an inclusive one-year warranty and comprehensive dealer support program.

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ware to activate underlining, high-intensity blinking characters, and reverse video.

With a color monitor, the IBM Personal Computer will support 16 foreground and eight background colors. In the medium-resolution graphics mode, screen resolution is 320 pixels (picture elements) across by 200 down. In the high-resolution graphics mode, resolution is 640 by 200 pixels. Text and graphics can be mixed, allowing you to label items in a graphics display.

One Centronics-compatible parallel printer port and one RS-232C serial I/O (input/output) port are standard. An asynchronous communications adapter ($150) enables you to connect a modem to the serial port.

IBM is even offering a Game Control Adapter ($55) that permits connection of user-supplied joysticks and paddles to the IBM Personal Computer.

Sales and Service

IBM's sales and service strategies show the computer giant's determination to develop quickly into a major force in the microcomputer market. Beginning this month, the company is marketing the Personal Computer nationwide in four ways:

- through Computerland retail stores
- through Sears, Roebuck and Company's new business-machine stores (IBM will train the Sears sales personnel)
- through a special sales unit in the IBM Data Processing Division (for high-volume sales)
- through IBM Product Centers, which will make provisions for installment purchases

Only four Product Centers exist now, but IBM has selected many more cities around the country as sites for future centers. "In the course of the next two years," said C B Rogers, Jr, IBM vice president and group executive of the General Business Group, "we expect to be fairly well represented."

IBM will offer a 5 percent discount on sales of 20 to 49 units, 10 percent on sales of 49 to 150 units, and 15 percent on sales of 151 units or more. Educational institutions will also receive discounts.

At a Glance

Product Name
The IBM Personal Computer

Manufacturer
International Business Machines Corporation
Information Systems Division
Entry Systems Business
POB 1328
Boca Raton FL 33432

When Available
October 1981

Where Available
Sears, Roebuck and Company's business-machines stores
Computerland stores
IBM Product Centers
IBM Data Processing Division (volume sales)

Components
System Unit
Size: width 20 inches, depth 16 inches, height 5.5 inches; weight (without disk drives) 21 pounds, (with two disk drives) 28 pounds
Electrical needs: 120 VAC
Processor: Intel 8088
Cycle Time: main storage, 410 nanoseconds; access, 250 nanoseconds
Memory: 40 K bytes of built-in ROM (read-only memory), 16 K bytes of user RAM (random-access read/write memory); expandable to 256 K bytes
Standard: keyboard for data and text entry; audio-cassette recorder connector; five expansion slots for memory, display, printer, communications, and game adapters; built-in speaker for music programming; power-on automatic self-test of system components; BASIC-language interpreter; 16 K bytes of user RAM (all user RAM is 9-bit parity memory)
Keyboard: 83 keys for data and text entry, 10 keys for numeric entry and cursor control, 10 special function keys, and ASCII characters and special graphics characters (total 256 characters); automatic repeat on all keys; adjustable typing angle; detachable six-foot coil cable
Disk drives: up to two 5-inch floppy-disk drives, 160 K bytes each

Operating Systems
IBM Personal Computer DOS (Microsoft)
CP/M-86 (Digital Research)
UCSD p-System (Softech Microsystems)

Software Available for IBM Personal Computer DOS
BASIC interpreter (Microsoft) standard; extended BASIC interpreter (Microsoft) $40; Pascal compiler (Microsoft) $300; VisiCalc (Personal Software) $200; Easywriter (Information Unlimited Software) $175; General Ledger, Accounts Receivable, Accounts Payable (Peachtree Software) $595 each; asynchronous communications support $40; Adventure (Microsoft) $30

Hardware Prices

System Unit, 16 K-byte RAM, keyboard	$1265
System Unit, 48 K-byte RAM, keyboard single floppy-disk drive, disk-drive adapter	2235
Monochrome video display	345
Combination monochrome-display adapter and printer adapter	335
Color-graphics-monitor adapter	300
16 K-byte memory-expansion kit	90
32 K-byte memory-expansion kit	325
64 K-byte memory-expansion kit	540
Disk-drive adapter	220
Disk drive (5-inch floppy disks)	570
Asynchronous communications adapter	150
Game-control adapter	55
Keyboard	270



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Go to work with powerful BASIC language tools—the CBASIC-2® business BASIC, or the Microsoft BASIC® interpreter.

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Since the entire system is only $1795, it won't be too long before the guy on the left has an OSBORNE 1 of his own. The same probably goes for the person reading this ad. In fact, we think it's inevitable.

The OSBORNE 1 includes a Z80A® CPU, 64K bytes of RAM memory, two 100 kilobyte floppy disk drives, a business keyboard, built-in monitor, IEEE 488 and RS232 interfaces for printers and other things that get connected to computers, plus CP/M, CBASIC-2, Microsoft BASIC, WORDSTAR, and SUPERCALC. The system is available from computer retailers nationally.



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26500 Corporate Avenue Hayward, California 94545
Phone (415) 887-8080 TWX (910) 383-2021

Circle 284 on inquiry card.

IBM's service plans should meet or exceed those offered by other microcomputer manufacturers. For a start, IBM offers a 90-day warranty. Owners can extend warranties to a full year for between 7 and 9 percent of the purchase price of various system components, or buy annual service contracts for 10 to 15 percent of the purchase price of components. For example, an extended warranty for the System Unit costs $88; a maintenance contract for the System Unit costs $112. For the System Unit, disk drive, and disk-drive adapter, an extended warranty costs $154, and a maintenance contract costs $196.

Service will be available at Sears, Computerland, and from the IBM Product Centers, regardless of where you bought the computer. Service contracts with the IBM Product Centers call for exchange of major system components. IBM will send a replacement keyboard, printer, or System Unit by courier within 48 hours of the owner's call.

Three Ways to Generate Software

Recognizing the advantage that an existing broad software base gives to CP/M-compatible, Radio Shack, and Apple computers, IBM plans to meet the problem head-on with a three-part strategy.

First, when the Personal Computer reaches stores this month, it will be accompanied by a software offer including some application programs ready to run with IBM DOS. Here's a quick look at what IBM is offering:

- IBM Personal Computer DOS. This CP/M look-alike from Microsoft offers the familiar "A>" prompt character along with features for copying files and disks, comparing files and disks, initializing disks, displaying a directory, renaming files, and other housekeeping chores. Although it has a debugger and a line editor, IBM DOS does not yet have an assembler. It seems safe to speculate that Microsoft is hard at work on that.
- a cassette-level enhanced Microsoft BASIC interpreter that supports input/output instructions, use of the keyboard, display, light pen, and printer, and many editing and mathematical functions.
- a disk-level Microsoft BASIC that provides extensions including more powerful graphics, date and time-of-day functions, and communication capabilities; the enhanced graphics include such features as point, circle, and get/put display, and increased light-pen support for design work ($40)
- a Pascal compiler, also from Microsoft ($300)
- VisiCalc, the electronic-worksheet program from Personal Software
- Easywriter, the word-processing program from Information Unlimited Software ($175)
- an asynchronous communications program ($40) (This is written in BASIC and is menu-driven; the menu includes an *option for the* Dow Jones Information Services, another for The Source, and another for teletypewriter-like communications. IBM soon will also offer a full subset of Model 3270 emulation capabilities so that the Personal Computer can appear to larger IBM systems as an IBM 3270 terminal.)
- general-ledger, accounts-payable, and accounts-receivable packages, from Peachtree Software, but with color and other enhancements for ease of use ($595 each)
- Adventure, the fantasy-simulation game, from Microsoft ($30)

The second part of IBM's software-development strategy is to offer Digital Research's CP/M-86 operating system and Softech Microsystem's UCSD p-System (which includes UCSD Pascal). Purchasers of these operating systems will have access to many third-party programs as they become available. IBM says it expects the availability of these operating systems to provide the opportunity for many current applications to be transferred to the IBM Personal Computer with minimal modifications. This approach will enable owners of the IBM Personal Computer to use a tremendous amount of software originally written for other common machines. Users can have everything that IBM offers without giving up software for the other two operating systems.

The third part of the IBM software strategy is to establish its own Personal Computer Software Publishing Department. The new department will solicit software from outside authors, both professional and amateur. IBM will send software-submission information packets to anyone who writes to IBM Personal Computer Software Submissions, Dept 765, Armonk NY 10504. IBM will also encourage its employees to write software for the personal computer (on the employees' own time). Authors will receive quarterly royalties based on actual sales.

A Shaking Out?

For those of us who dislike giants, the IBM Personal Computer comes as a shock. I expected that the giant would stumble by overestimating or underestimating the capabilities the public wants and stubbornly insisting on incompatibility with the rest of the microcomputer world.

But IBM didn't stumble at all; instead, the giant jumped leagues in front of the competition. Although the IBM Personal Computer has not (as of this writing) reached store shelves, it already seems to hold a firm position in the field. Its prices seem to compare favorably with available 16-bit S-100 systems. Furthermore, the cost of an IBM Personal Computer configured for word processing is not much more than that of an Apple II Plus, an Intertec Superbrain, or most other 8-bit machines fully equipped for word processing. A superior machine from the start, the IBM Personal Computer should grow in capability as outside vendors begin producing peripheral devices and add-on hardware for special applications.

In fact, the only disappointment about the IBM Personal Computer is its dull name. One rumor claimed that IBM referred to this computer internally as the Acorn. To me, it looks more like a Mighty Oak.■

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Circle 351 on inquiry card.

Build an Intelligent EPROM Programmer

Steve Ciarcia
POB 582
Glastonbury CT 06033

Longtime followers of the activities in Ciarcia's Circuit Cellar may remember an incident I wrote about a few years ago. My friend Jerry needed to program an EPROM (erasable programmable read-only memory) device in a hurry for a demonstration at his computer club. The EPROM-programming arrangement we devised gave me the idea for the article "Program Your Next EROM in BASIC" (March 1978 BYTE, page 84), in which I presented a design for an inexpensive programming circuit and told how to drive it with software written in a high-level language.

EPROM technology has advanced considerably since then. In 1978, the type-2708 EPROM chip, which requires a three-voltage power supply, was just becoming established, replacing the hard-to-program type-1702 EPROM device. Not only was the 2708 easier to program, it also held more data: 1 K (1024) 8-bit words, compared to 256 8-bit words stored by the 1702 EPROM.



Photo 1: *Complete intelligent EPROM-programming system, consisting of the Z8-BASIC Microcomputer, the EPROM-programming interface of figure 4b, and a video-display terminal.*

The 2708 EPROM has been replaced in most new designs by the single-voltage type-2758 EPROM, and a number of higher-capacity devices that require only a single-voltage power supply have been developed and made available by several manufacturers. These are the type-2716 (2 K 8-bit words, or 16 K bits), type-2732 (4 K 8-bit words), and type-2764 (8 K 8-bit words) EPROMs. The 2716 has become especially popular, partly because its 2 K bytes are sufficient memory space for storing most bootstrap loaders, command monitors, and simple utility programs; and partly because the 2716 is usually priced under $10.

The 2758, 2716, and 2732 EPROMs are members of the same family of components, sharing a common pinout specification. With only minor modifications to the wiring, a designer can allow different-capacity memory devices to be plugged into the same socket on a circuit board. This versatility also means the same basic circuit can serve in several applications.

My previous article on EPROMs suggested using an interpreted BASIC

program to drive the EPROM-programming circuit. This idea did work, but it took a long time to program a 2708 EPROM. If you wanted to program more than a few 2708s, you would have been wise to pack a box lunch for the occasion. The BASIC program demonstrated the algorithm for programming an EPROM, but a machine-language driver program was needed for practical large-scale EPROM programming.

The slow speed for programming, or "burning," 2708s this way results from the need to iterate the write pulse 100 times for each byte location. Each byte in the 2708 must be written for at least 100 ms (milliseconds) to assure stability of the stored data. However, this 100 ms duration must consist of 100 separate, pulsed write sequences, each lasting only 1 ms. All 1024 byte locations must be addressed in sequence while a +25 V programming pulse is applied for 1 ms for each address. The cycle is then repeated 100 times.

The 2716, on the other hand, requires only one loop through all the addresses, instead of 100 loops. While each location is being addressed, a 50 ms programming pulse is applied, usually timed by a one-shot (monostable multivibrator). The 50 ms, single-loop programming conditions fall well within the speed capabilities of BASIC, and no machine-language driver routine need be written for serious use.

Using a program essentially the same as the one presented in the original article (running under an 8 K BASIC interpreter on a Z80 microprocessor with a 2.5 MHz clock rate), a 2716 can be completely burned in 154 seconds, requiring 75 ms per location. The minimum time required with a machine-language driver is 103 seconds, or 50 ms per location. The difference is hardly noticeable.

Because EPROMs are so widely used, I thought it was about time to write another article on them, featuring the 2716. First, I'll discuss why EPROMs are used and how they work, and then I'll describe the design of my new EPROM-programming circuit.

What is different about this new circuit? I decided to "unbundle" the system and design the EPROM programmer as a stand-alone, intelligent unit. By incorporating the Z8-BASIC Microcomputer (my July-August Circuit Cellar project), we can easily put together a stand-alone 2716 programmer with capabilities that rival those of units costing ten times as much. (See "Build a Z8-Based Control Computer with BASIC, Part 1," July 1981 BYTE, page 38, and "Part 2," August 1981 BYTE, page 50.)

Whys and Wherefores of EPROM

A personal computer, even in its minimum configuration, always contains some user-programmable memory or RAM (random-access read/write memory), usually in the form of semiconductor memory integrated circuits. This memory can contain both programs and data. Any machine-word-level storage element within the memory can be individually read or modified (written) as needed.

Any of several kinds of electronic components can function as bit-storage elements in this kind of memory. TTL (transistor-transistor logic) type-7474 flip-flops, bistable relays, or tiny ferrite toroids (memory cores) are suitable, but all cost too much, are hard to use, and have other disadvantages.

In personal-computer and other microprocessor-based applications, the most cost-effective memory is made from MOS (metal-oxide semiconductor) integrated circuits. Unfortunately, data stored in these semiconductor RAMs is volatile. When the power is turned off, the data is lost. Many ways of dealing with this problem have been devised, with essential programs and data usually stored in some nonvolatile medium.

In most computer systems, some data or programs are stored in nonvolatile ROM (read-only memory). A semiconductor ROM can be random-

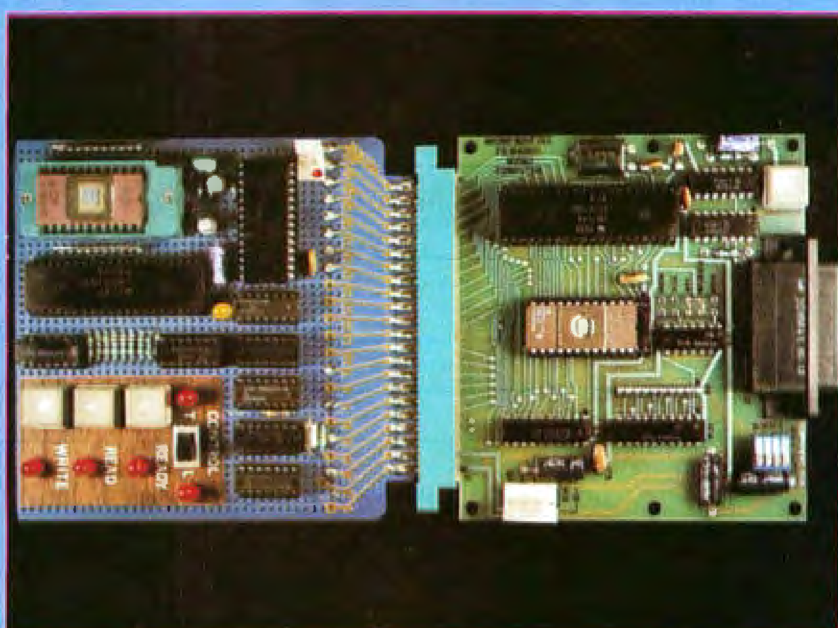


Photo 2: *Closeup of the EPROM programmer. On the right is the Z8-BASIC Microcomputer circuit board with the program-controller software resident in the onboard EPROM. On the left is the prototype type-2716 EPROM programming interface. It includes a control panel, an operator display (LEDs), a zero-insertion-force EPROM socket, and a 4 K-byte buffer memory.*

ly accessed for reading in the same manner as the volatile memory, but the data in the ROM is permanent. In a mask-programmed ROM, the data that can be read is determined during the manufacturing process. Whenever power is supplied to the ROM, this permanent data (or program) is available. In small computer systems, ROM is chiefly used to contain operating systems and/or BASIC interpreters—programs that don't need to be changed.

Pins / Mode	$\overline{CE}$/PGM (18)	$\overline{OE}$ (20)	V_{PP} (21)	V_{CC} (24)	Outputs (9-11,13-17)
Read	V_{IL}	V_{IL}	+5	+5	D_{out}
Standby	V_{IH}	Don't care	+5	+5	High impedance
Program	Pulsed V_{IL} to V_{IH}	V_{IH}	+25	+5	D_{in}
Program Verify	V_{IL}	V_{IL}	+25	+5	D_{out}
Program Inhibit	V_{IL}	V_{IH}	+25	+5	High impedance

Table 1: *Voltages present at specified pins of the 2716 during the five modes of operation. V_{IL} must be in the range −0.1 V to +0.8 V; V_{IH} must be in the range +2.0 V to V_{CC} + 1.*

Another type of ROM is the PROM (programmable read-only memory). A PROM component is delivered from the factory containing no data. The user decides what data he wants it to contain, and permanently programs it with a special programming device. Once initially programmed, PROMs exhibit the characteristics of mask-programmed ROMs. You might label such PROMs as "write-once" memories.

The ultraviolet-light-erasable EPROM is a compromise between the "write-once" kind of PROM and the volatile memory. You can think of the EPROM as a "read-mostly" memory, used in read-only mode most of the time but occasionally erased and reprogrammed as necessary. The EPROM is erased by exposing the silicon chip to ultraviolet light at a wavelength of 2537 angstroms. Conveniently, most EPROM chips are packaged in an enclosure with a transparent quartz window. (I once wrote about a different kind of "read-mostly" memory, the EAROM: electrically alterable read-only memory. An EAROM is erased by purely electrical means, without resorting to ultraviolet light. See "Add Non-volatile Memory to Your Computer," December 1979 BYTE, page 36.)

How the EPROM Works

EPROMs made by Intel Corporation and several other manufacturers store data bits in cells formed from stored-charge FAMOS (floating-gate avalanche-injection metal-oxide-semiconductor) transistors. Such transistors are similar to positive-channel silicon-gate field-effect transistors, but with two gates, as shown in figure 1a. The lower, or "floating," gate is completely surrounded by an insulator layer of silicon dioxide, and the upper "control" or "select" gate is connected to external circuitry.

The amount of electric charge

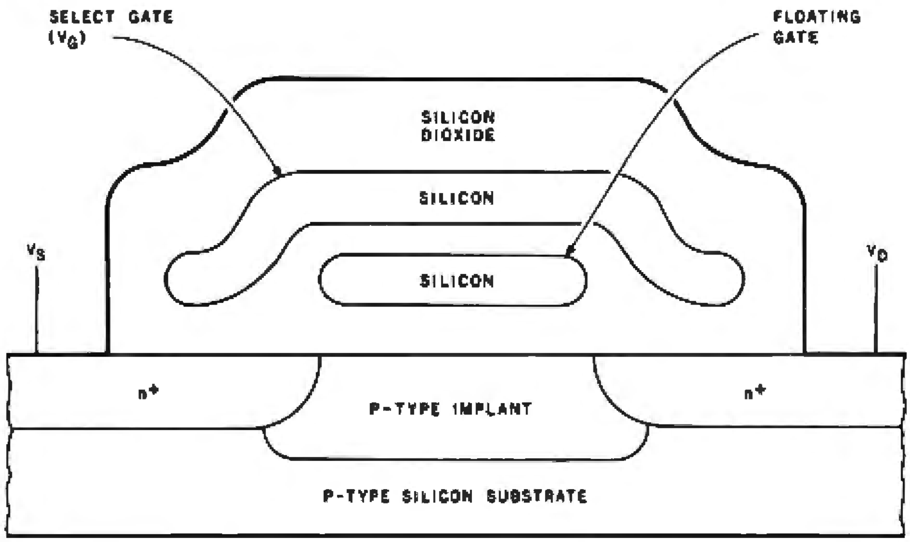


Figure 1a: *Physical structure of one bit-storage cell in a 2716 EPROM. The cell consists of a FAMOS (floating-gate avalanche-injection metal-oxide semiconductor) field-effect transistor manufactured in a stacked-gate configuration. During programming, a voltage placed on the select gate creates an electric field within the structure. The field raises the energy levels of electrons passing through the channel from drain to source enough that some of the electrons are able to tunnel through the silicon-dioxide insulator and accumulate on the floating gate.*

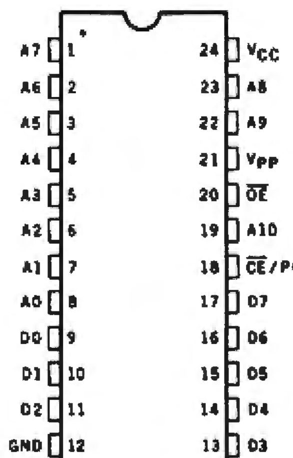


Figure 1b: *Pinout specification of the type-2716 EPROM (erasable programmable read-only memory) integrated-circuit package.*

stored on the floating gate determines whether the bit cell contains a 1 or a 0. Charged cells are read as 0s; uncharged cells are read as 1s. When the EPROM chip comes from the factory, all bit locations are cleared of charge and are read as logic 1s; each byte contains hexadecimal FF.

When a given bit cell is to be burned from a 1 to a 0, a current is passed through the transistor's channel from the source to the gate. (The electrons, of course, move the opposite way.) At the same time, a relatively high-voltage potential is placed on the transistor's upper select gate, creating a strong electric field within the layers of semiconductor material. (This is the function of the +25 V charging potential applied to the 2716.) In the presence of this strong electric field, some of the electrons passing through the source-drain channel gain enough energy to tunnel through the insulating layer that normally isolates the floating gate. As the tunneling electrons accumulate on the floating gate, the gate takes on a negative charge, which makes the cell contain a 0.

When data is to be erased from the chip, it is exposed to ultraviolet light, which contains photons of relatively high energy. The incident photons excite the electrons on the floating gate to sufficiently high energy states that they can tunnel back through the insulating layer, removing the charge from the gate and returning the cell to the 1 state.

Programming the 2716

The 2716 EPROM contains 16,384 (16 K) bit-storage cells configured as 2048 individually addressable bytes. This organization is often called "2 K by 8." The completely static operation of the device requires no clock signals.

The pinout specification of the 2716 is shown in figure 1b, and a block diagram of its internal structure is shown in figure 1c.

The 2716 has five different operating modes, for which the input-voltage requirements are shown in table 1. The read, standby, and program modes are the ones I'll discuss in detail, since the program-inhibit and program-verify modes are important primarily in high-volume applications.

In the *read* mode, two control inputs are used to select the chip after the processor has selected the memory address. The $\overline{\text{OE}}$ (output enable) line is provided mainly as a means of jointly selecting a bank of several 2716s, perhaps by a connection to the memory-read line on the system bus. The $\overline{\text{CE}}$/PGM (chip enable/program) input is decoded and used as the primary device-selecting line.

After the logic level present on the $\overline{\text{CE}}$/PGM pin has been brought low, the $\overline{\text{OE}}$ input should also be brought low. Then 120 ns (nanoseconds) elapse before the addressed data is available on the data-output pins. This is sufficiently fast to be compatible with other types of memory devices in most systems, allowing direct connection of the 2716 to the system bus for reading data, as shown in figure 2a on page 40.

The 2716 can be placed in the static *standby* mode to reduce the power consumption without increasing the access time once it is addressed. With a TTL high level applied to $\overline{\text{CE}}$/PGM, the output lines assume a high-impedance condition. It doesn't matter what voltage is present on $\overline{\text{OE}}$.

In the *program* mode, particular bit cells are induced to contain 0 values. Both 1s and 0s are present in the data word presented on the data lines of the 2716, but only the presence of a 0 causes action to take place.

When the V_{PP} power-supply input is placed at a potential of +25 V and the $\overline{\text{OE}}$ input is at a high level (V_{IH}), the TTL-level data to be programmed for a specific address is set up on the 2716's data lines, and the address is set up on the address lines A0 through A10. After a setup time of at least 2 µs (microseconds), a high TTL-level programming pulse 50 ms long is applied to the $\overline{\text{CE}}$/PGM input. Addresses to be programmed may be specified in any order.

The 50 ms programming pulse must be applied once for each location to be programmed. Under no circumstances should a constant high level be applied to the $\overline{\text{CE}}$/PGM input in the program mode. Repeated 50 ms pulses to the same location are acceptable, but any pulse width greater than 55 ms might destroy the chip. (The minimum pulse width is 45 ms.) Using a nonretriggerable one-shot (monostable multivibrator) to generate the pulse is one simple protective measure.

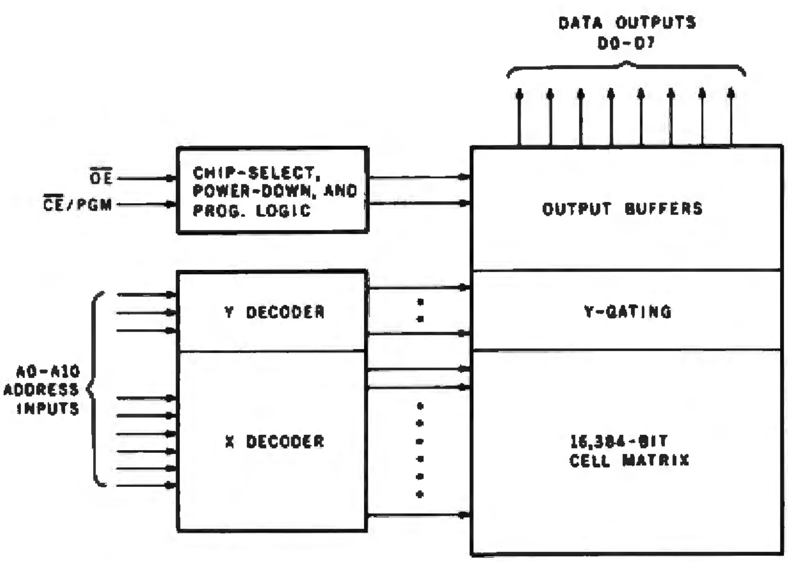


Figure 1c: *Block diagram of the internal structure of the type-2716 EPROM.*

A Simple EPROM Programmer

As we have previously seen, in the read mode the 2716 may be connected

directly to the system's address and data buses. It's not so easy, however, in the program mode.

Because of the setup-time interval that must elapse after the address data are presented, the programming pulse must come at an instant that doesn't fit too well within the synchronous operating constraints of the typical computer system bus. This limitation is most easily overcome by using three parallel output ports to communicate with the EPROM. The address and the data can be held constant while the programming pulse is applied. Figure 2b shows a block diagram of this scheme, and figure 3 shows the schematic diagram of an actual circuit that uses this principle, which can be used with almost any personal computer.

The simple EPROM-programming circuit uses two integrated circuits besides the EPROM: the Intel 8255 PPI (Programmable Peripheral Interface) and a type-74121 one-shot. The 40-pin 8255 contains three separate I/O (input/output) ports. Twenty-four I/O lines can be programmed for various input, output, and control functions. (For more information on the 8255 PPI, see "Interfacing the S-100 Bus With the Intel 8255," by David L Condra, October 1979 BYTE, page 124, or the Intel *Component Data Catalog*.)

In this application, I set up the 8255 to operate in two different configurations. When programming, ports B and C contain the address, and port A contains the data. All three ports are set up for output. When verifying the contents (in read mode) after programming, ports B and C again contain the address, but port A is set for input to read output data from the 2716.

The 8255 is relatively simple to use. Its four internal registers for ports and control are accessed just like any other I/O device. Using a combination of chip-select and address-decoding logic, particular combinations of logic levels on the A0 and A1 lines designate the specific register being addressed, as shown in table 2. The data word written into the mode-control register configures the particular functions of the 24 I/O bits.

Setting all three ports for output is accomplished by writing hexadecimal 80 into the mode-control register. The other combination, B and C set for output with A set for input, is arranged by loading hexadecimal 90 into the mode-control register. These two control codes are the only ones required.

The EPROM interface in figure 3 requires the operator to select the read or program mode by the position of a toggle switch. In the read mode, the V_{pp} power input will be at +5 V, and $\overline{CE}$/PGM and $\overline{OE}$ will be at logic 0. In the program mode, with the switch closed, V_{pp} will be at +25 V, $\overline{OE}$ will be at logic 1, and the one-shot will be strobed for each successive location. The driver program which coordinates this effort

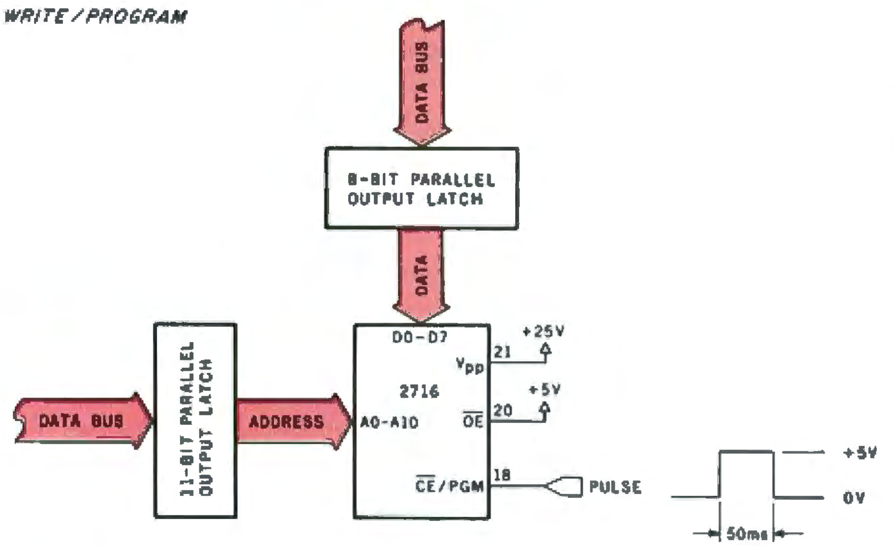


Figure 2a: *For read-mode operation, the 2716 EPROM is fast enough that it can be directly connected to the address and data buses of most microcomputer systems. The $\overline{OE}$ (output enable) line is usually used as a means of jointly selecting a bank of 2716s, while the $\overline{CE}$/PGM (chip enable/program) line is used to select the particular integrated circuit that is to be addressed.*

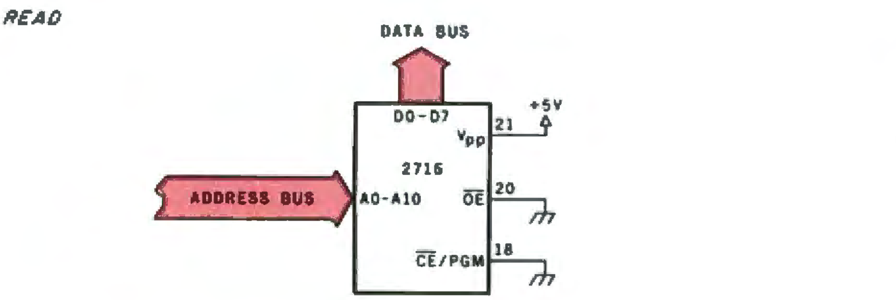


Figure 2b: *In the write-program mode, the need for an asynchronous programming pulse necessitates the use of external data latches, driven by the output ports of the controlling computer system.*

Register	Address Bits A0	A1
Port A	0	0
Port B	0	1
Port C	1	0
Mode-Control Register	1	1

Table 2: *Addressing of port and mode-control registers in the Intel 8255 Programmable Peripheral Interface.*

will be essentially the same as that for the more sophisticated EPROM programmer yet to be described.

An Intelligent Programmer

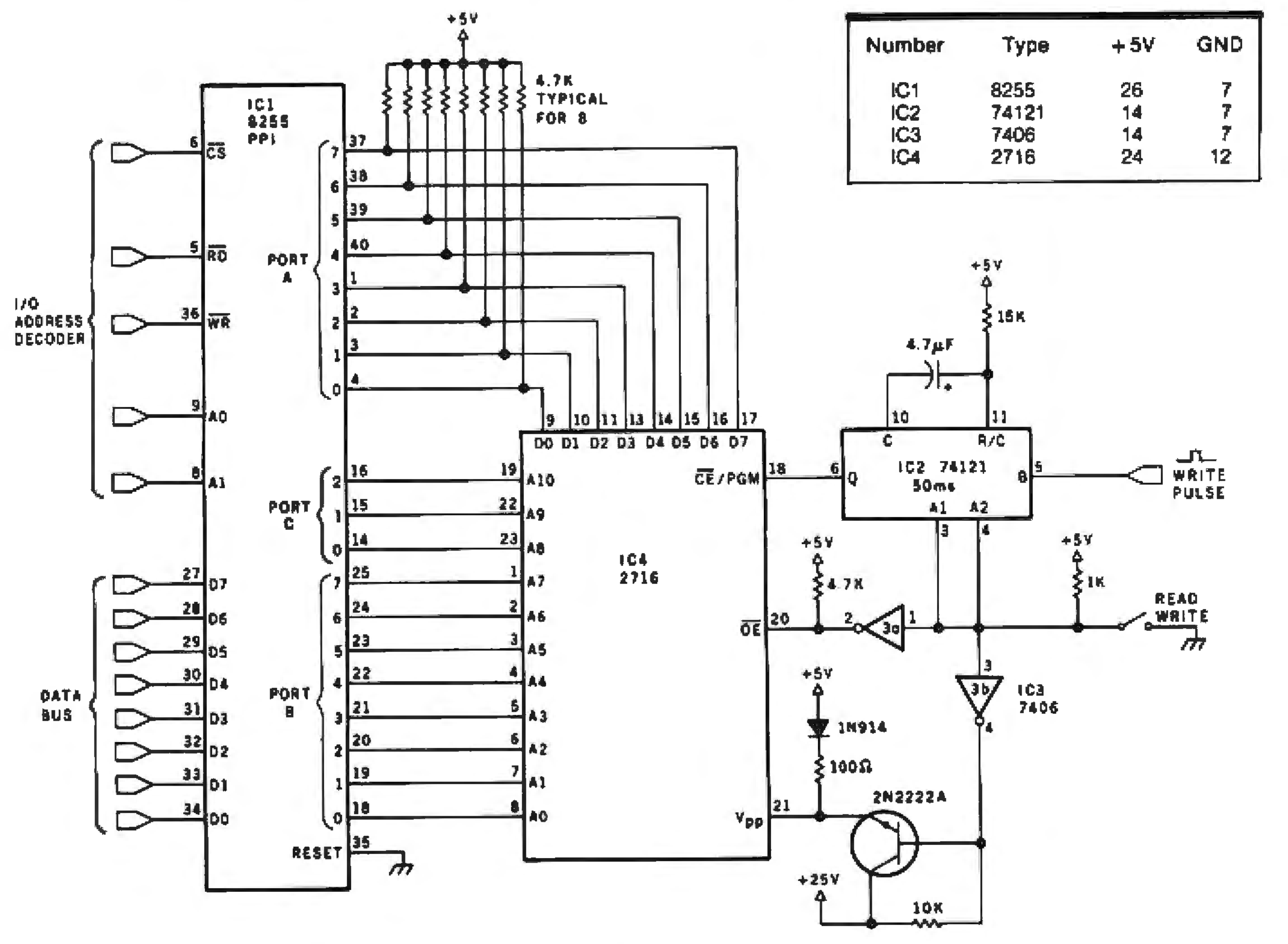
The 2-chip EPROM programmer previously described is an *interface* designed to be attached to a program-development-type computer system. It can do just as much as the one I am about to discuss. However, what I have in mind is better than a mere EPROM-programming interface: an intelligent EPROM programmer, a stand-alone device that functions only as a programmer.

In my opinion, such a programmer should be able to perform the following tasks: accept raw input data by various means and store this data in a buffer memory, read a previously programmed EPROM and store the contents in the buffer, write the contents of the buffer into another EPROM, and compare the contents of the same or a different EPROM chip to the buffer. In essence, these are standard load, program, and verify functions consistent with any reasonably useful 2716 programmer.

Photo 1 on page 36 shows the prototype of such a device. The intelligence for this programmer is supplied by a Z8-BASIC Microcomputer, a single-board computer specifically configured for use as a controller in dedicated applications. Using this Z8-based controller board, I was able to program and test the driver software directly and easily.

The final configuration consists of the Z8 board, 4 K bytes of expansion memory, the EPROM-programming circuit of figure 3, three pushbutton switches, and some LEDs (light-emitting diodes) added to communicate with the operator. The pushbuttons L, V, and W activate the load, verify, and write functions, respectively. The three LEDs next to them are labeled Read, Write, and Ready. Two more LEDs, labeled T and L (for terminal and local) are placed adjacent to the Control slide switch. I'll explain them later.

The intelligent EPROM programmer has two operating modes. With the Control switch in the L (local) position, the programmer receives all its commands through the pushbutton switches. With the Control switch in the T (terminal) position, the programmer expects to receive commands from a video terminal or teletypewriter connected to the Z8-BASIC Microcomputer's RS-232C connector. In this terminal mode, you can examine the buffer contents, directly change or introduce new



Number	Type	+5V	GND
IC1	8255	26	7
IC2	74121	14	7
IC3	7406	14	7
IC4	2716	24	12

Figure 3: *Schematic diagram of a simple EPROM-programming circuit that is intended to be driven from an external large (program-development-type) computer system.*

data, and execute the standard read, write, and verify functions by keyboard commands. In addition, this mode facilitates serial entry of data directly into the buffer.

The local mode emulates the pushbutton operation of typical commercial EPROM programmers. Pressing L (load) will cause the device to read an EPROM inserted into the ZIF (zero insertion force) integrated-circuit socket and store the data in 2 K bytes of the 4 K-byte read/write-memory buffer. (The buffer has enough capacity to store all the data in a type-2732 EPROM, making possible yet more versatility.) Pressing W (write) will make the device program the 2 K bytes of data from the memory buffer into an erased EPROM inserted into the ZIF socket. Pressing V (verify) will cause the Z8 program device to compare the contents of the buffer to the EPROM. The LEDs indicate the current status and inform the operator when a function has been completed. All these operations and control assignments are under program control. Their meanings and functions can easily be changed in software to meet your specific requirements.

Programmer Hardware

The EPROM-programming hardware consists of two basic sections: memory expansion for the Z8-BASIC Microcomputer (shown in figure 4a), and the EPROM-interface section (shown in figure 4b).

After the EPROM-programming software has been written and debugged (which is done using the BASIC interpreter), it can itself be placed into an EPROM, which can then be plugged into the Z8 board's Z6132 memory socket. With the onboard read/write memory removed to accommodate the EPROM, a separate buffer memory must be added to the Z8 board to hold the data read from or written into the 2716 being processed. This can be provided by the original or another Z6132 quasi-static 32 K-bit memory device and two other chips. IC1 in figure 4a is the Z6132, and IC2 and IC3 function as address decoders. As configured, the 4 K-byte expansion memory resides at hexadecimal addresses 8000 through 8FFF.

The EPROM-interface hardware shown in figure 4b is essentially the same as that in figure 3, with a few more "bells and whistles." As previously described, the 8255 PPI is attached to provide three parallel ports. Instead of using four incremen-

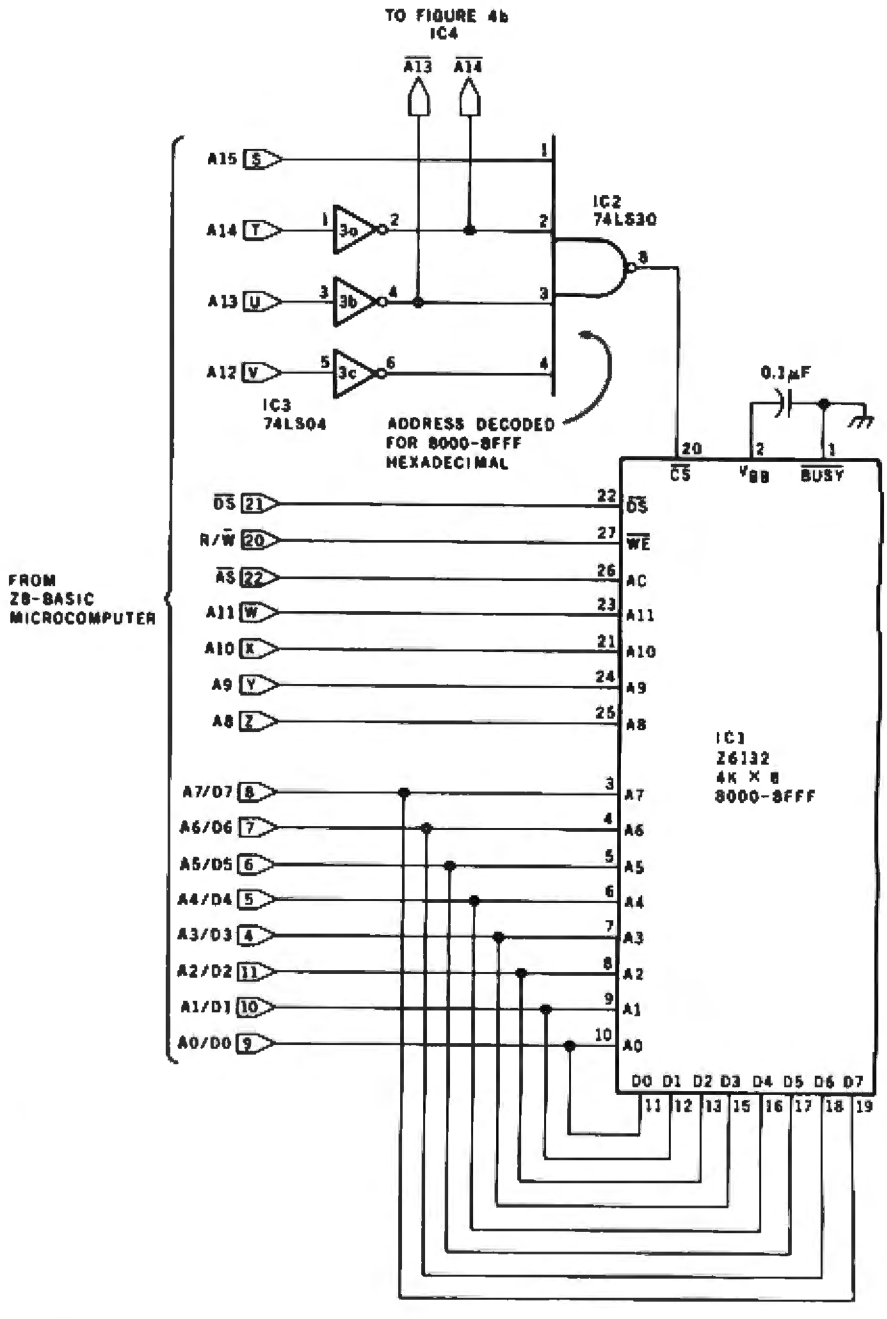
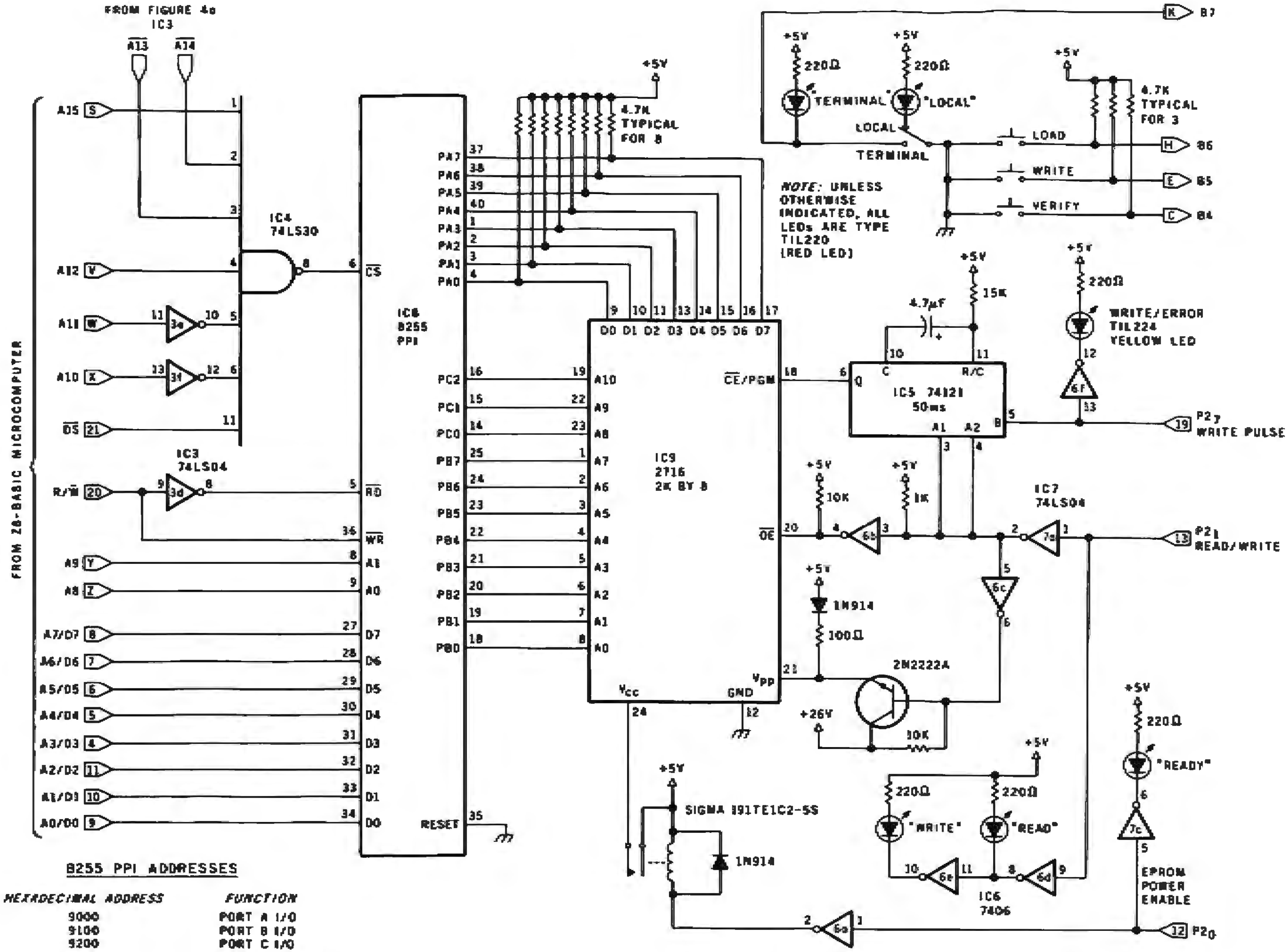


Figure 4a: *Schematic diagram of the buffer-memory section of the intelligent EPROM programmer. This circuit expands the read/write memory capacity of the Z8-BASIC Microcomputer, and it may be used independently of the EPROM-programming interface.*

Number	Type	+5V	GND
IC1	Z6132	28	14
IC2	74LS30	14	7
IC3	74LS04	14	7
IC4	74LS30	14	7
IC5	74121	14	7
IC6	7406	14	7
IC7	74LS04	14	7
IC8	8255	26	7
IC9	2716	see schematic diagram	



8255 PPI ADDRESSES

HEXADECIMAL ADDRESS	*FUNCTION*
9000	PORT A I/O
9100	PORT B I/O
9200	PORT C I/O
9300	MODE CONTROL

Figure 4b: *The EPROM-interface section of the intelligent EPROM programmer. This connects to the circuit of figure 4a and the Z8-BASIC Microcomputer, forming a versatile means of burning programs into a type-2716 EPROM chip.*

tally adjacent addresses to designate the mode-control-register and port locations, I conserved hardware and addressed the four ports as follows: hexadecimal 9000, port A; hexadecimal 9100, port B; hexadecimal 9200, port C; and hexadecimal 9300, mode control.

Other differences in the circuit include computer control of the read/write function and the supply of power to the EPROM. Rather than making you manually turn off the power to insert or extract a 2716, the EPROM programmer controls the power through a relay. The READY LED indicates when the power is off (the LED will be lit). The three control signals come from output port 2 provided on the controller board. Bit 0 is the power control (0 = off, 1 = on), bit 1 is the read/write control (0 = read, 1 = write), and bit 7 provides the program pulse to the one-shot (a transition from low to high and back to low). The Control switch and the three pushbutton switches are read as bits 4 through 7 of an I/O port memory-mapped into hexadecimal address FDE8 (decimal 65000). This input port is also provided on the Z8 board.

The intelligence for the EPROM programmer is supplied by a Z8-BASIC Microcomputer.

Software Control

The driver program for the programmer is written in tiny BASIC and resides in EPROM on the controlling Z8 board. The routine is very straightforward and can easily be rewritten to run on another BASIC interpreter, should you care to connect the EPROM interface to a different computer. The entire program is too complex to cover in this article; it includes a lot of code necessary merely for screen formatting and operator interaction in the terminal mode. Let's confine our attention to the less involved routines which allow automatic programming control in the local mode.

The code for the local-mode control routines is given in listing 1 on page 47. Flowcharts of the constituent parts of the listing are shown in figures 5 through 8. Essentially, the program consists of a supervisory input scanner and four subroutines. The supervisor reads the pushbutton and slide switch inputs and transfers control to the appropriate subroutine to execute the corresponding function. The functions include reading the EPROM and storing the data values in the buffer, writing the buf-

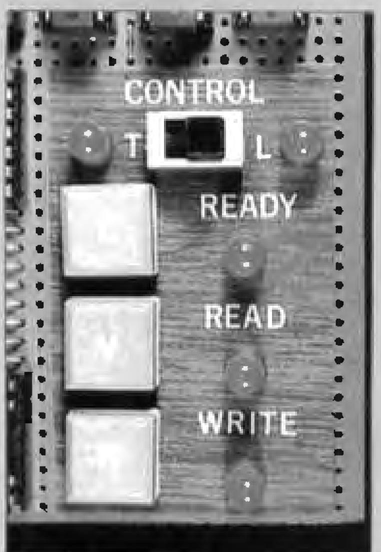


Photo 3: *Closeup of the prototype control panel. The L, V, and W pushbutton switches control the load, verify, and write functions, respectively. The T and L indications next to the slide switch stand for terminal and local. In local-mode operation, no video-display terminal or teletypewriter is necessary, and all EPROM programming and verification can be accomplished with only these controls.*

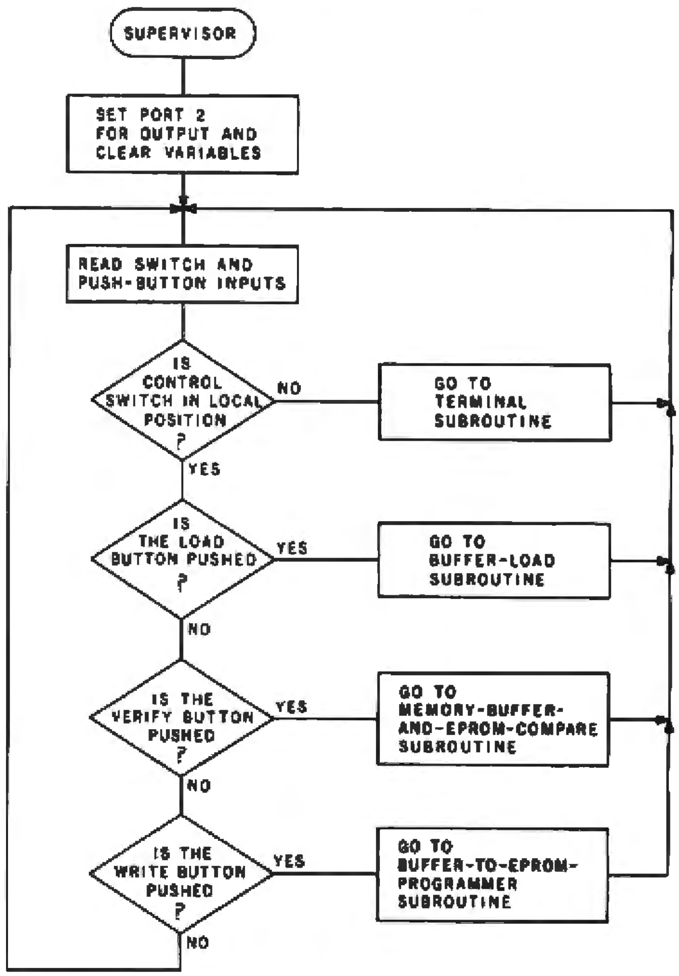


Figure 5: *Flowchart of the command-input, user-interface section of the EPROM-programming software, as shown in listing 1.*

fer contents to the EPROM, comparing the buffer and EPROM values, and transferring control to an interactive routine that communicates with the operator through a keyboard and display (terminal mode). The flowcharts indicate the sequence.

Conclusion

As the technology of EPROM manufacturing continues to be developed, I will keep a close eye on the possible need for circuits to use new components. Perhaps in another few years I'll be writing about interfacing and programming 1-megabyte EPROM chips.

I shall also be investigating other projects using the Z8-BASIC Microcomputer as a component that can give additional flexibility and

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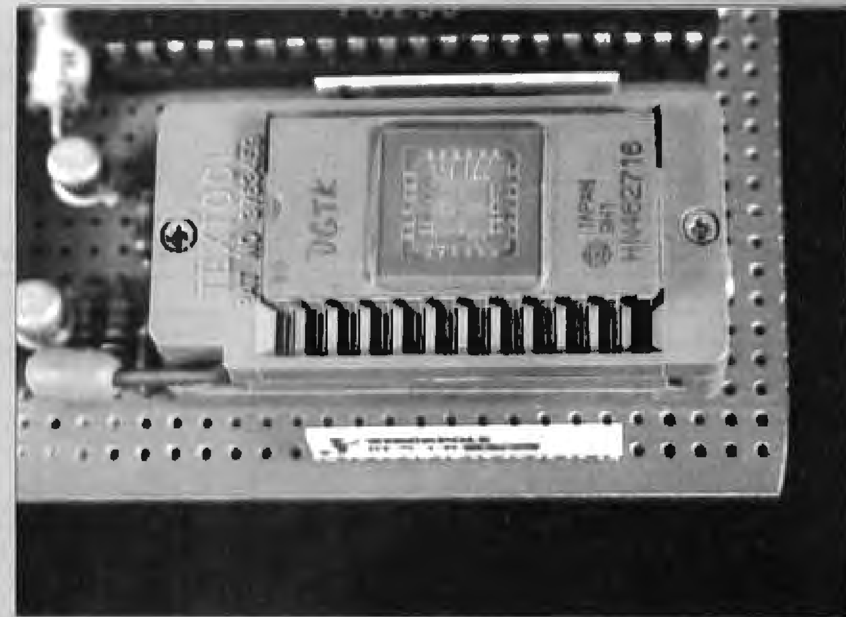


Photo 4: *Closeup of ZIF (zero insertion force) socket. When the lever on the lower left is in the vertical position, the two metal contacts touching each IC (integrated circuit) pin are spread far apart. The IC therefore requires no (zero) extra effort to separate the contacts during insertion or removal. When the lever is down, as shown, the two contacts are clamped against each IC pin, and the IC is held fast with good electrical contact.*

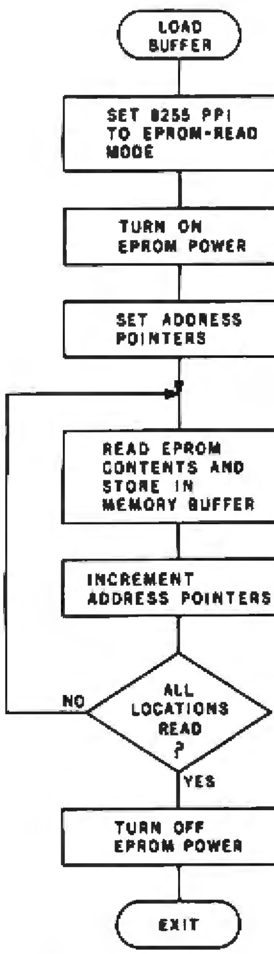


Figure 6: *Flowchart of the subroutine to load the EPROM programmer's buffer memory from a previously programmed EPROM chip.*

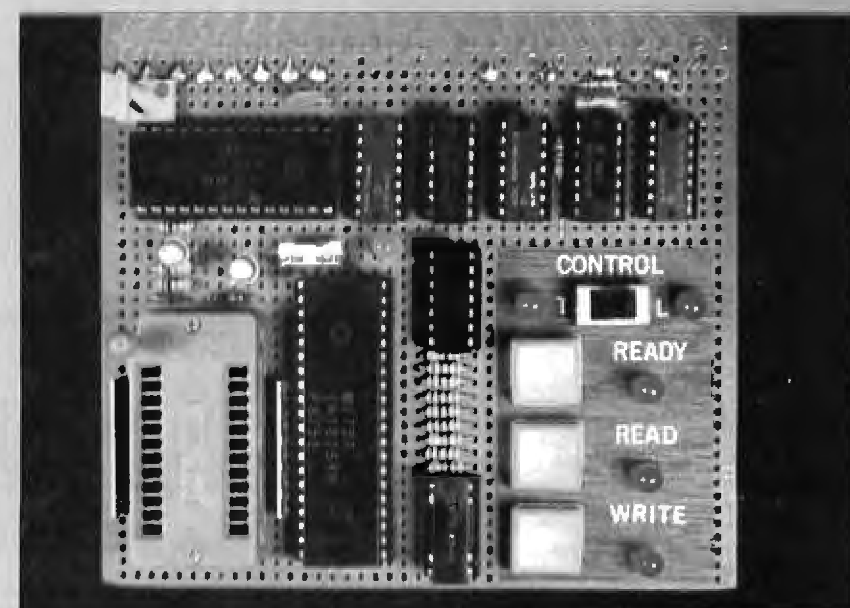


Photo 5: *Closeup of the prototype EPROM-programmer interface. Other than the control panel and ZIF socket, the interface essentially consists of a 4 K-byte buffer memory and 3 programmable I/O ports. Users wishing merely to expand the original Z8-BASIC Microcomputer need add only these sections.*

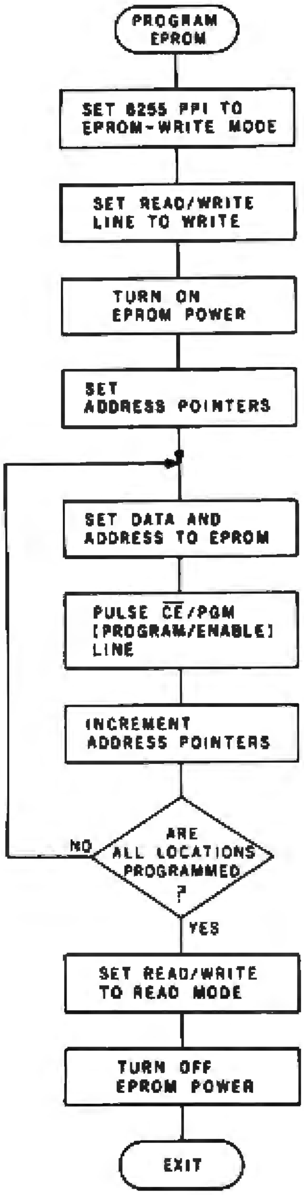


Figure 7: *Flowchart of the routine to write data from the buffer into a new or erased 2716 EPROM chip.*

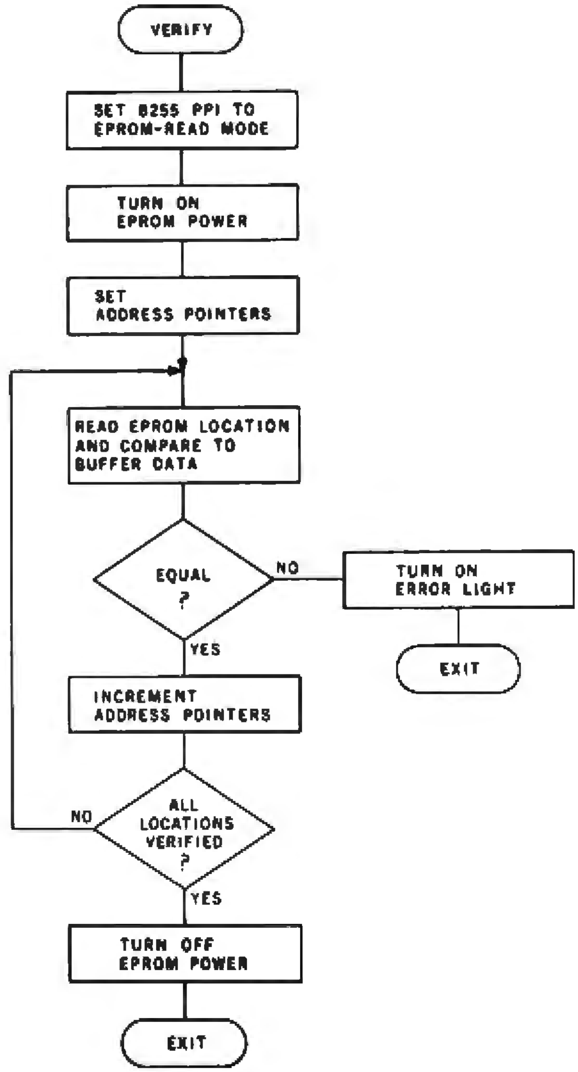


Figure 8: *Flowchart of the routine that verifies correct programming of the EPROM.*

Listing 1: *Program routines to control various functions of the intelligent EPROM programmer, written for the BASIC/Debug interpreter of the Zilog Z8671 single-chip micromputer found in the Z8-BASIC Micromputer.*

```
100 REM INTELLIGENT EPROM PROGRAMMER
102 REM USING CIRCUIT CELLAR BASIC COMPUTER/CONTROLLER BOARD
103 REM CLEAR VARIABLES AND CHECK KEYPAD ENTRIES
105 @246=0 :@2=0
110 A=0 :B=0 :X=0 :Y=0
130 A=@65000
135 REM B7-TERM/LOCAL,B6-LOAD,B5-WRITE,B4-VERIFY
140 IF AND(A,%80)=0 THEN 5000
150 IF AND(A,%40)=0 THEN 1000
160 IF AND(A,%20)=0 THEN 2000
170 IF AND(A,%10)=0 THEN 3000
200 GOTO 130
1000 REM READ/LOAD BUFFER SUBROUTINE
1005 REM CLEAR VARIABLES AND SET 8255 FOR I/O READ
1010 X=0 :Y=0 :A=0 :B=0
1020 @%9300=%90
1025 REM MEMORY BUFFER STARTS AT 8000 HEX
1030 @2=1
1040 GOSUB 1100
1050 @B=@%9000
1060 GOSUB 1300
1070 GOTO 1040
1100 B=(32768+X+(Y*256))
1110 @%9100=X :X=X+1 :GOSUB 1200
1120 @%9200=Y
1130 RETURN
1200 IF X=256 THEN Y=Y+1 :X=0
1210 RETURN
1300 IF B=34815 THEN @2=0 :GOTO 130
1310 RETURN
2000 REM WRITE CONTENTS OF MEMORY BUFFER INTO EPROM
2010 X=0 :Y=0 :A=0 :B=0
2015 REM SET PROGRAMMER TO WRITE MODE AND TURN ON EPROM POWER
2020 @2=3
2030 @%9300=%80
2040 GOSUB 1100
2045 REM SET DATA AND ADDRESS ON 8255 AND PULSE WRITE STROBE
2050 @%9000=@B
2060 @2=131 :@2=3
2070 GOSUB 1300
2080 GOTO 2040
3000 REM VERIFY CONTENTS OF EPROM TO MEMORY BUFFER
3020 X=0 :Y=0 :A=0 :B=0
3025 REM SET PROGRAMMER TO READ MODE AND TURN ON EPROM POWER
3030 @%9300=%90
3040 @2=1
3050 GOSUB 1100
3055 REM COMPARE EPROM AND MEMORY -- IF WRONG, TURN ON ERROR LIGHT
3060 IF @%9000<>@B THEN @2=128 :GOTO 130
3070 GOSUB 1300
3080 GOTO 3050
5000 REM ENTER TERMINAL EXERCISOR PROGRAM HERE
5010 GOTO 130
:
```

Text continued from page 45:

capability to an otherwise simple project.

Next Month:

If you've wanted to use a switching-type power supply in your projects but didn't know how to go about it, you will have an opportunity to find out as I explore this topic in November. ■

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Ultra-Low-Cost Network for Personal Computers

Ken Clements and Dave Daugherty
Pacific Polytechnical Corp
POB 2780
Santa Cruz CA 95063

Ten years ago, computer "hackers" listened with glee to predictions that technological advances would soon allow them to buy their very own computers. Indeed, the seers predicted, the computers of the future would fit into a spare bedroom or basement and wouldn't even require air conditioning. The word went out: *start* saving $100,000 to be ready when that great time came.

The time came with a vengeance. Today you can hardly take twenty paces around a technical organization, school, or office without bumping into or being addressed by yet another computer.

One of the sad outcomes of this exponential growth was creation of the computer junkie, the unfortunate soul who went out and bought each of the newest computers he or she could afford. The junkie ended up with a basement full of equipment and a computer habit that could be satisfied only by more spending.

Just when the future was looking grim for these computer junkies, salvation took form and appeared on college campuses. Perhaps the best explanation came from a recruiter from the giant Xmumblex Corp, who took a young graduate aside and whispered, "I have just one word for you: *networks.*"

The big-computer companies and an army of computer scientists apparently will be going network crazy for the next ten years. This development thrills the computer junkies because it provides more computer "stuff" to get excited about. And, the junkies calculate, if they could get their own personal networks going, they might be able to string together all the "coldware" collecting dust in their basements.

What stops most people from going ahead with their own networks is complexity, both in terms of cost and technical considerations. A typical coaxial network "box" may be as difficult to build and interface as was the computer you wanted to network. This stumbling block is particularly large for the computer junkie who owns no two pieces of hardware that are the same. He must come up with a new interface for each one.

But almost all those pieces of hardware have at least one RS-232 serial port. RS-232 was designed to provide point-to-point communication, and it requires some central manager "box" to produce a network. But with as little as one diode per port, two resistors for the ends, and a −12-volt (V) source, you can turn RS-232 into ULCNET, the Ultra-Low-Cost Network.

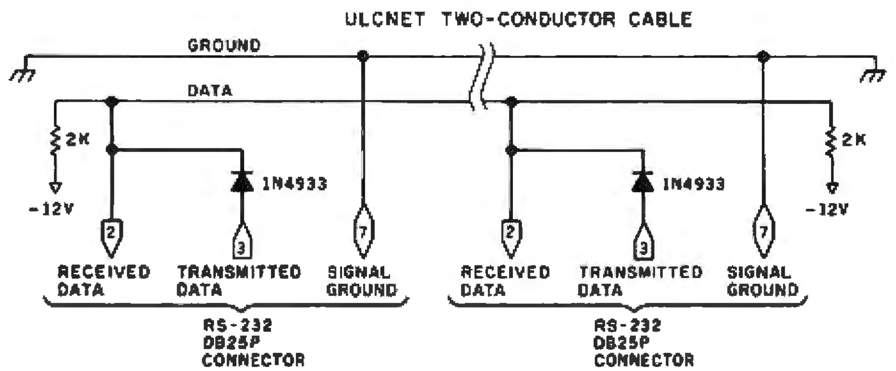


Figure 1: *Simplest version of ULCNET. The addition of a diode, cable, and terminating resistors converts RS-232 ports into a basic network for personal computers.*

Simple Technique

The primary technique for this transformation is shown in figure 1. It is amazingly simple: just connect a diode in series with the transmit line, then connect the receive line and the diode to your cable. At the ends of the cable you will need resistors to "pull down" the line to −12 V and to help soak up reflections. Serial communications via RS-232 are usually not too fast, so the type of cable and exact terminations are not critical.

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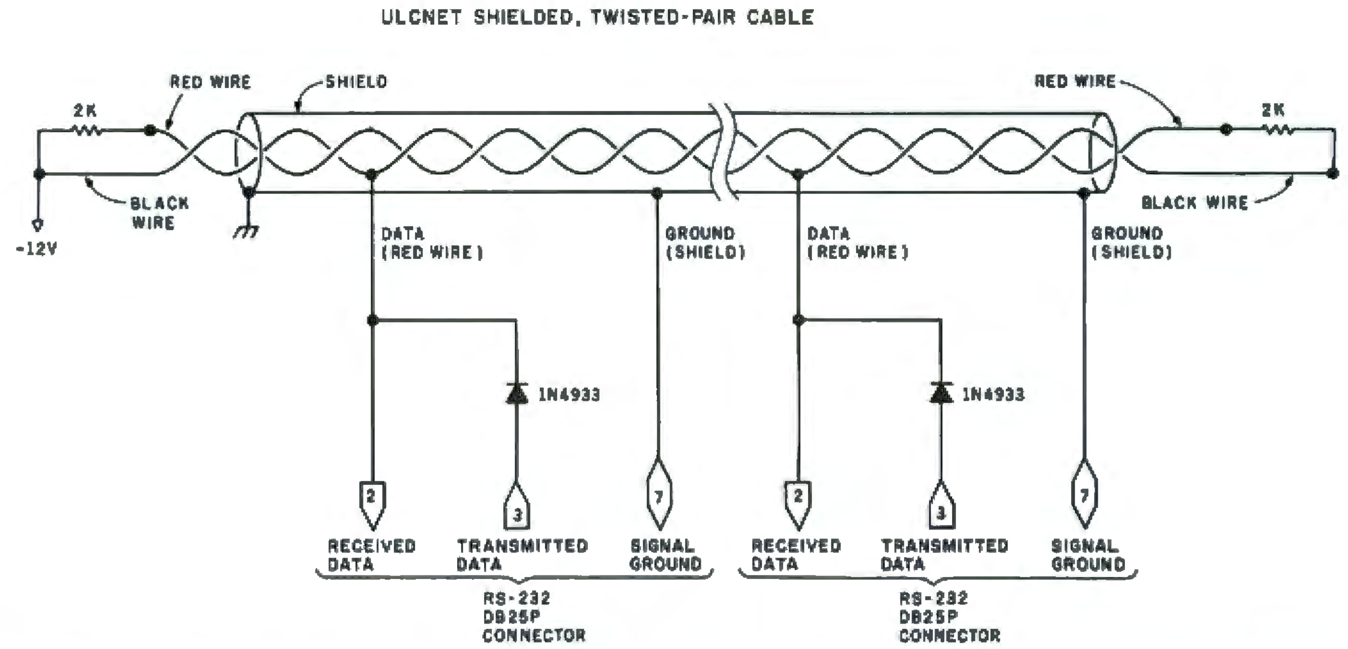


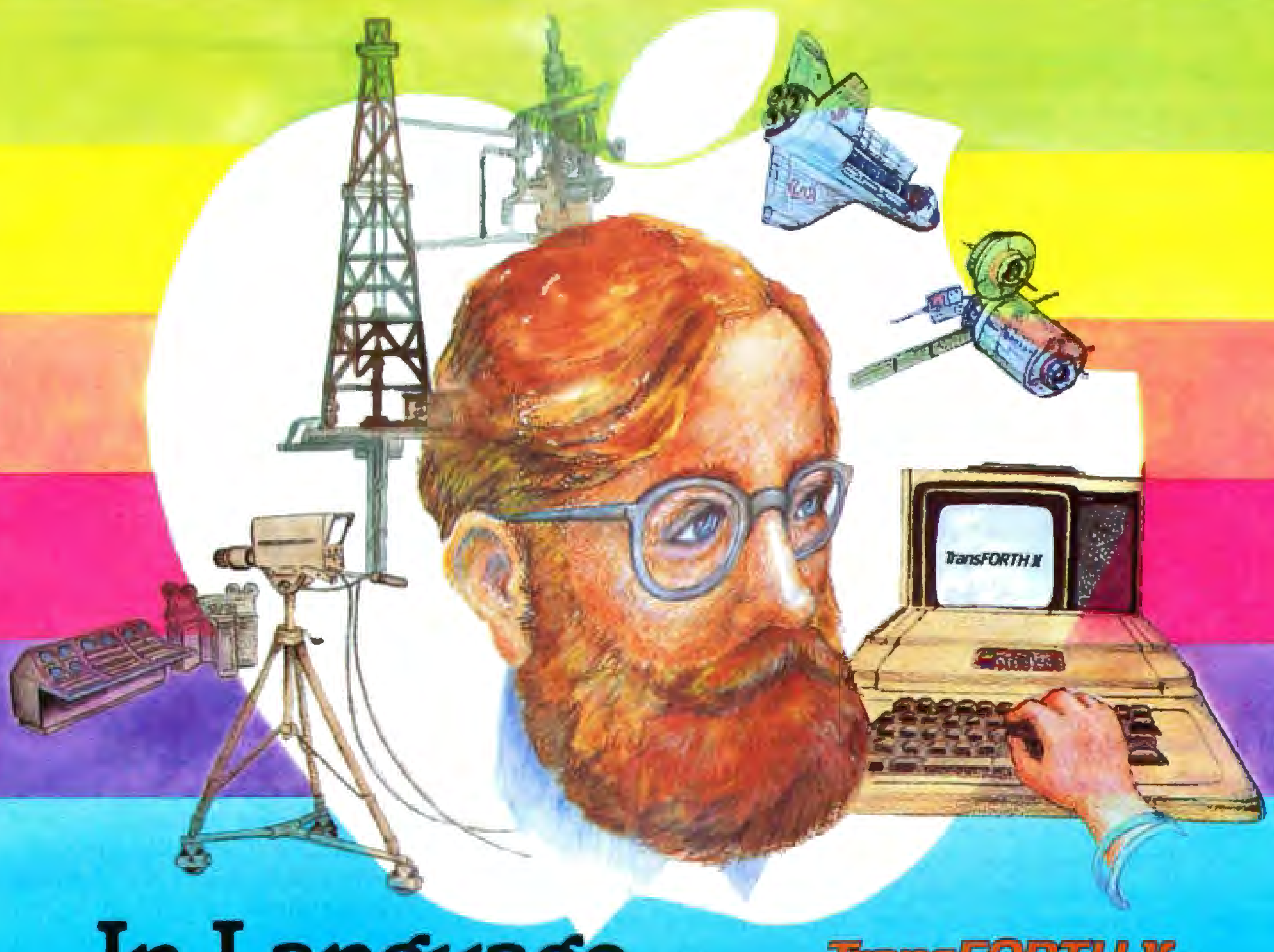
Figure 2: *ULCNET for two-wire shielded cable. In this version, a single −12 V power supply is specified, and power is transmitted to the pull-up resistors via one conductor of the cable.*

For most applications, it is easy to use shielded twisted-pair cable for the net. This allows one of the wires in the pair to carry the −12 V needed by the termination resistors at the end of the cable. An example of wiring the termination is shown in figure 2. This technique assumes that somewhere along the line, the black wire in the pair is connected to −12 V and the shield is grounded.

When characters are sent through an ULCNET port, they are received at all the ports on the net, including the port that did the sending. However, if two or more ports send different messages at the same time, the transmitting ports will each receive something other than what they sent: the logical OR of the two messages. This allows an extremely important property, namely *collision detection* (a property also used in Xerox's Ethernet).

The ULCNET uses the fact that an RS-232 port holds its transmit line at negative voltage when not transmitting, and then pulses the transmit line positive at the start of a character. The RS-232 standard defines a positive level as a transmitted 0 and a negative level as a binary 1. In other words, a character starts with a 0, followed by a byte of code transmitted low-order bit first. At least one binary 1 is inserted after each byte-long character, and it is called the stop bit.

The termination resistors on the ULCNET provide the negative level, and each port may "pull" the line to a positive level by the start pulse of a character. In terms of bits, the resistors supply the 1s, and the ports supply the 0s.



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The speed and distance limits of the ULCNET come from a combination of the drive-current limitations of an RS-232 port and the load each receiver puts on the net. The limits lead to a three-way trade-off of distance, speed, and number of receivers. For example, you might use the *ULCNET* at 19,200 bps (bits per second) for six devices separated by 20 feet, or you might connect three devices with two miles of wire and run at 300 bps.

Improvements

Some simple modifications can be made to expand the network capability. The first modification gets the number of receivers out of the trade-off equation. Figure 3 shows an alternate ULCNET connection in which an op amp (operational amplifier) is used to buffer the incoming signal. This reduces to almost nothing the load each node places on the network, thereby allowing as many connections as desired on the net.

Some RS-232 ports have +12 V and −12 V supplied on pins 9 and 10 of their DB25 connector (these can be used to power the op amp). Most, however, do not, so the user will need to run a pair of wires to the power supply of the computer. If some other power source is used, the user must be sure its ground reference is the same as pin 7 of the RS-232 port.

Figure 3 also shows a circuit that drives the DTR (data terminal ready) input of the RS-232 port. This circuit is used to detect activity on the net, and it will assert (pull high) DTR if the net is busy. The circuit works by charging C1, a 0.1 μF capacitor during the start bit of a character. The capacitor will then discharge through the 330-kilohm (kΩ) resistor R1 when characters are no longer being transmitted. The choice of values for these two components is set by the slowest data rate to be used on the net. The choice shown was picked for 1200 bps operation. If 2400 bps is desired as the lowest rate, then halve R1's value. The resistor can be scaled in this manner for the lowest transfer rate desired. Table 1 suggests resistor values for various data rates, but plan to experiment.

The purpose of the *busy flag* circuit shown in figure 3 is to relieve the software of checking the condition of the net, and to provide a signal that can be used with an interrupt-driven system. (These techniques are discussed later.)

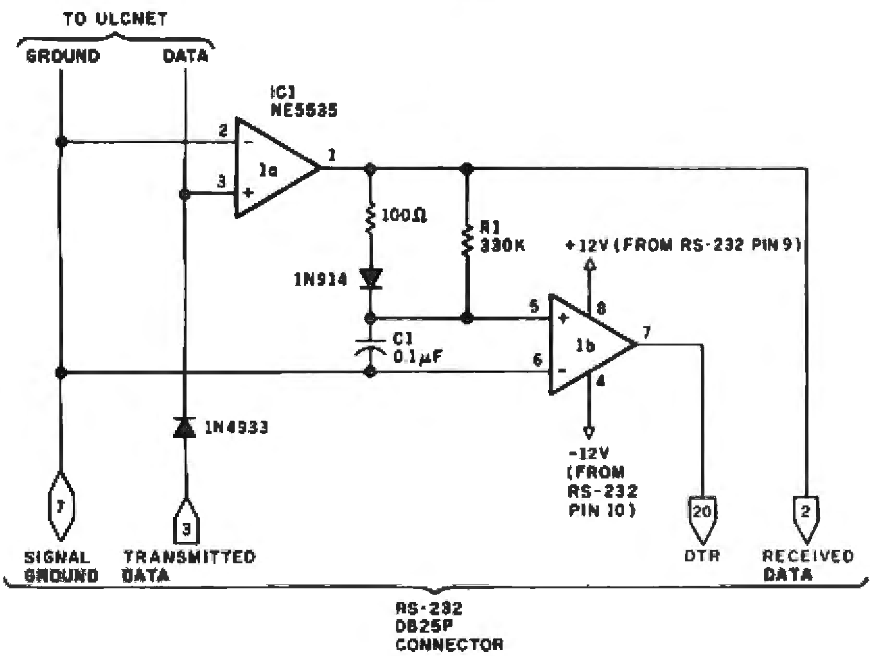


Figure 3: *Simple modifications expand network capacity. An operational amplifier reduces the load placed on the net by each node, so that a virtually unlimited number of nodes can be used. Resistor R1 and capacitor C1 control the op-amp comparator to signal that the network is busy. The components shown can be used with speeds as low as 1200 bps; see table 1 for alternate selections.*

Data Rate (bps)	Size of R_1 (kΩ)
1200	330
2400	160
4800	82
9600	39
19.2 k	22
38.4 k	10
76.8 k	5.1
153.6 k	2.2

Table 1: *Suggested resistor values for running ULCNET at various speeds. Experimentation is suggested.*

Aiming for Speed

Figure 4 is included for those who crave speed. Here, the drive limitation is overcome by using a power FET (field-effect transistor) to drive coaxial cable. The cable can be either standard 50-Ω coax, or the 75-Ω coax commonly used in cable TV operations. Whichever you choose, you *must* use a matching resistor (50 Ω or 75 Ω) on *each* end of the cable.

In this form of the ULCNET, the logical 0 is represented by a +12 V level, and the logical 1 is at 0 V. The same busy-detect circuit is used, and all of the network techniques will remain the same. This version of ULCNET is included for those who have very fast controller devices on their ports and want to operate in the 50 kbps to 1 Mbps range.

To make this fast version work, it is important to have a very solid source of +12 V that can put out about one amp for a very short time. The fuse included in figure 4 is meant to shut down the connection if the computer turns on the power FET and leaves it on. If not corrected, this error condition would cause the entire net to halt.

One way to set up a network is shown in figure 5. This setup would allow all the computers to share the hard disk and the printer. The computer directly connected to the hard disk and printer would be partially

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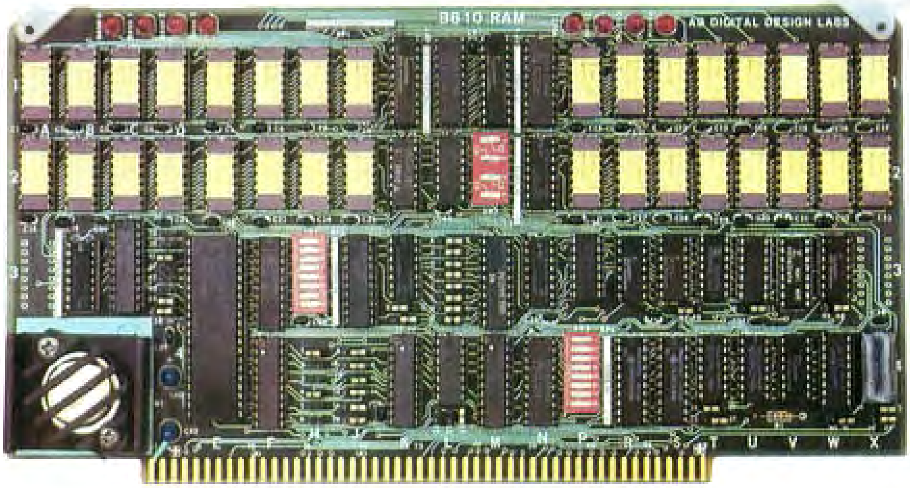
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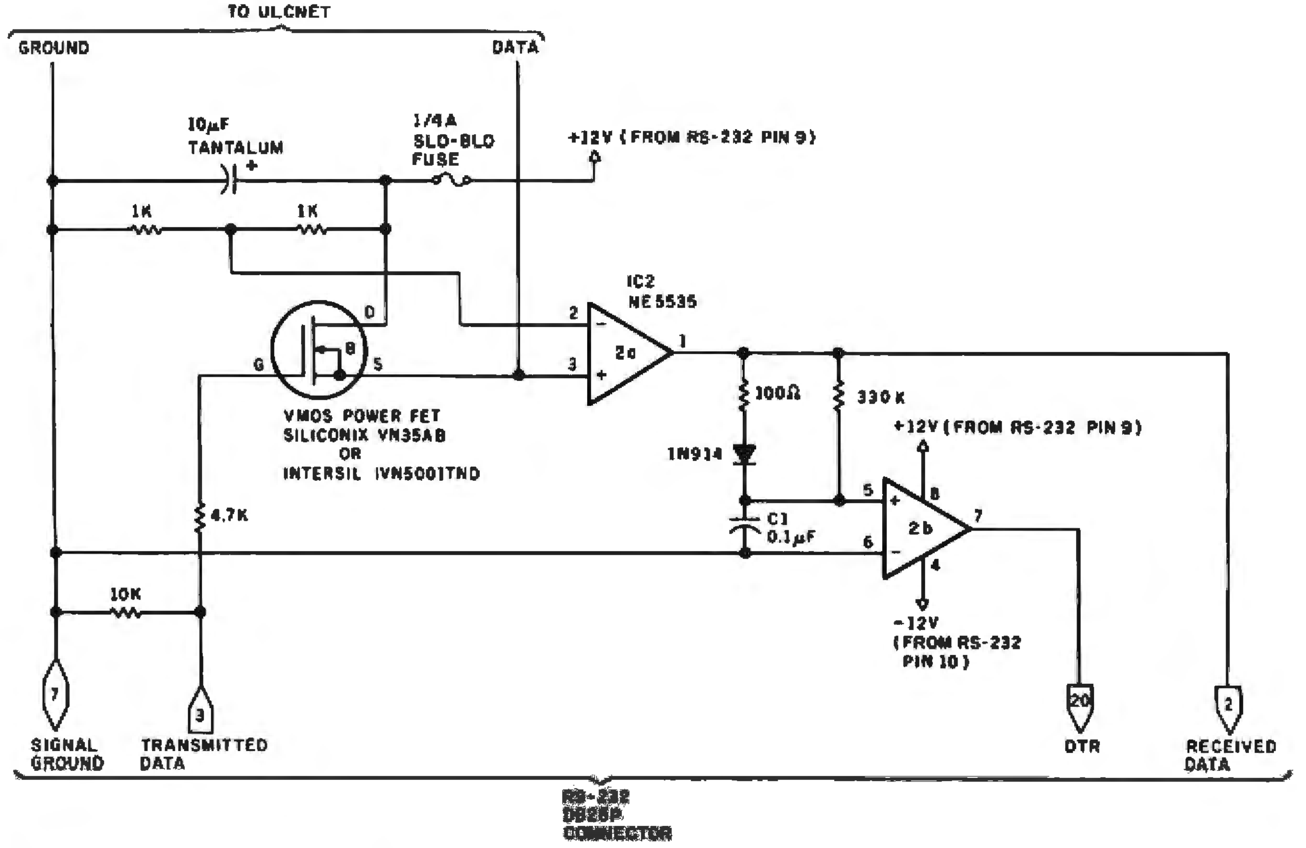


Figure 4: *Fast version of ULCNET. The primary limitation of driving power is overcome by installing an output transistor at each port. The transmitter shown may draw as much as 1 A from the −12 V supply, for short periods.*

dedicated to servicing the requests for these resources.

Design Issues

Now that we've discussed the hardware for the ULCNET, let's look at some of the issues involved in designing software for the network. These issues are: node-addressing concepts, message formats, task layering, low-level transmission and reception, communication protocols and error recovery, dialogue pipes, special types of networking communications, and networking under multitasking operating systems.

First let's define a node as any device connected to the ULCNET that has the ability to transmit information, receive information, or both.

If there are more than two nodes on a net, some mechanism is needed to uniquely specify the destination of transmitted information. This need is fulfilled by assigning to each node a unique numeric address. A single digit may be sufficient to specify the node for which a message is intended.

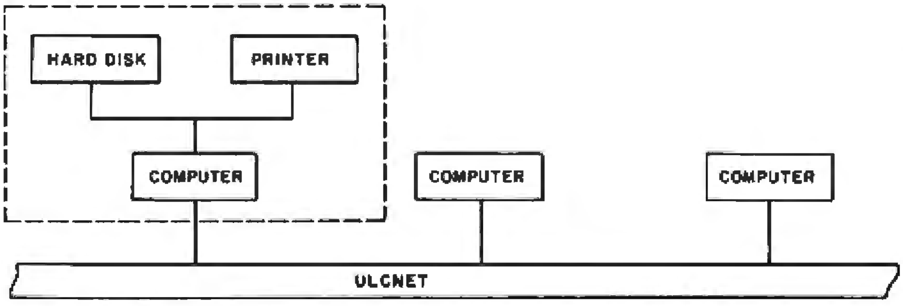


Figure 5: *One possible ULCNET configuration. In this example, the mass storage and printer on one computer system can be shared by several other systems.*

Many mechanisms can be used to inform the node's software of its particular address. The possibilities include establishing a switch setting on an input port, including the information in the software for each node (but each node would then need a unique version of the network software), or having the software query the user for an address during initialization.

An address does not necessarily have to be a number, as long as it can be uniquely recognized. It could be a character string such as EVA or SHIRLEY, but you must be willing to pay the cost of pattern matching in order to adopt this scheme.

A *nameserver* mechanism allows the nicety of character strings for addresses without sacrificing the advantage of number matching for decoding addresses. The nameserver consists of a file and a program on a node with mass storage that associates an ASCII (American Standard Code for Information Interchange) string with an address number. The nameserver

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SOT	TO ADDRESS	FROM ADDRESS	MESSAGE NUMBER	BYTE COUNT	MESSAGE I D	DATA	CHECKSUM

Figure 6: *Proposed message format. Various fields are included in each message to help the network software ensure reliability of the system.*

accepts requests for registration, deregistration, and name queries.

Special *generic addresses* also can be set aside for special purposes. For instance, the nameserver could be assigned a generic address to be used by all nameserver-related messages, making it unnecessary to know which node the nameserver is actually on.

Another generic address could be set aside to represent a *broadcast* message—one that all nodes on the network would want to receive. A typical use of a broadcast message is sending a company-wide memo to all employees on the network. The generic address eliminates the need to address the same memo to each person on the net.

Special types of nodes such as mass-storage nodes or printers can have their own addresses. For example, the address M might be reserved for the printer node. If there is only one printer on your net, M would mean that printer. If there is more than one printer on the net, an additional field called the logical printer number could be used to specify the printer for which the message is destined.

Message Formats

A message is a predetermined sequence of fields by which two nodes communicate. A message normally consists of several parts: the header, the body, and some kind of error-checking mechanism, such as checksum, at the end.

The structure allows for much variation. The basic component for constructing a message usually is a byte. A field is defined as one or more bytes that designate a particular section of a message. Typical fields in a message are shown in figure 6 and explained below.

- **SOT:** start of transmission. This byte is useful for informing all receivers that the beginning of a message is now on the net and that the next byte will be the address byte. Obviously, the byte must not be confused with bytes in the middle of a message.
- **To Address:** the address of the intended receiver.
- **From Address:** the address of the node that transmitted the message. As will be shown later, this field is important for sending acknowledgments back to the transmitter.
- **Message Number:** a unique number that distinguishes one message from the next. The usefulness of this field will be illustrated in the sections of this article dealing with duplicate messages.
- **Bytecount:** tells a receiver how many bytes to expect in the message body. It can be used as a receive loop counter, to be decremented each time a byte is received. When the counter equals zero, the user knows the checksum byte will follow immediately.
- **Message ID:** distinguishes three types of messages within a network system. The *data message* contains the essential information to be transmitted from one node to another. The *message acknowledgment* acknowledges a data message, and the third type of message, ACKACK, acknowledges a message acknowledgment.
- **Data:** zero or more bytes of information that follow the Message ID.
- **Checksum:** the error-checking byte, computed as the n-bit sum of all the bytes in the message (except the SOT byte and the checksum itself). The transmitter sums up all the bytes in its transmitted message and "ships out" the lower n bits of that sum as the last byte of the message. Meanwhile, the receiver does the analogous operation on the message it receives. If all the characters were received correctly, the receiver's lower n-bit sum should match the transmitter's checksum.

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Layering the Tasks

The network software can be broken up into three separate layers for implementation (see figure 7). These layers are the basic transmitter and receiver subroutines, the protocol layer, and the application program. Breaking up the network software in this manner is useful because it allows the implementer to concentrate on a subset of network functions without having to give much consideration to the rest of the functions. As an added benefit, the layered structure limits the software modifications needed in order to bring up networking capability for particular network tasks and particular machines.

As an example, let's say network software is to be brought up on two of the same type of microcomputers, each having a different serial interface. Subroutines in the transmitter/receiver layer that specifically deal with the serial interface are the only parts of the network software that need changing. On the other end, a printer-application program and a disk-write program should be able to use the same protocol layer and transmitter/receiver layer.

The Transmitter

A buffer and a byte count are the necessary parameters this routine needs from the protocol layer. The transmitter should neither know nor care what type of message is in the buffer. First, the transmitter will need to know if anyone else is currently using the network. In an interrupt environment, this can be determined by a flag set when a character is received and reset when a carrier detect interrupt occurs. If the flag is reset, therefore, it shows that the network is not in use.

If the transmitter is to be implemented without the aid of interrupts, it will be necessary to wait the length of time needed to receive one character (based on the data-transfer rate). If no characters are received in this time, it is assumed no one is in the middle of transmission.

Once it has been determined the network is not busy, the transmitter must send out the SOT field. A

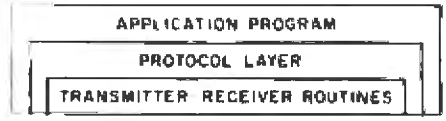


Figure 7: *Network protocol is based on the layer concept. Applications programs deal at a high level by letting the underlying layers do the 'dirty work.*

potential "race" problem resulting in a collision could occur at this point since two transmitters could conceivably start this transmission simultaneously.

Because the network is set up so that transmitters receive what they transmit, the received character should always be compared to the character that was just transmitted. If the two characters do not match, a collision has occurred. Later we will decide how to recover from such a collision.

Assuming the transmitter received what it transmitted, it continues to send out bytes until all, including the checksum, have been sent. If the transmitter is interrupt-driven, it may want to set a flag to inform the protocol layer that transmission was successful. For a transmitter running without interrupts, this information could be returned as a parameter to the routine that called the transmitter.

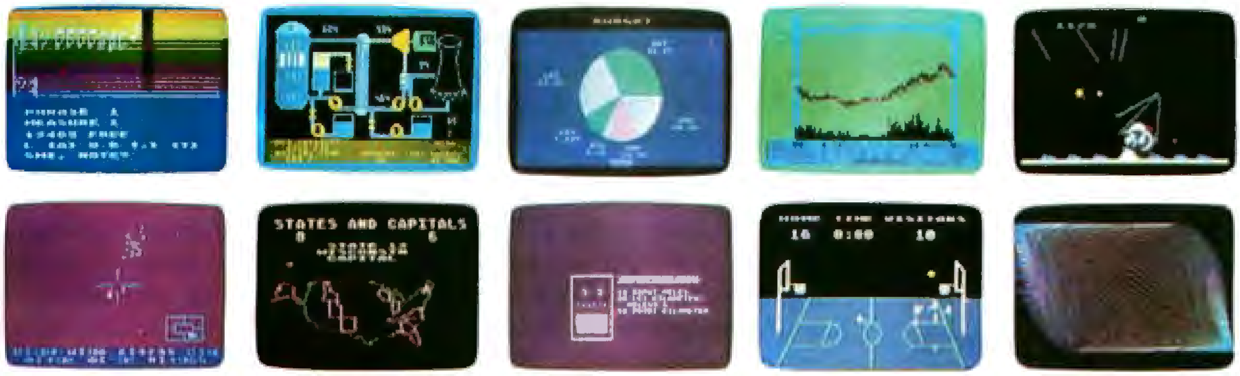
The Receiver

A receiver activated by interrupts will be able to synchronize with the beginning of a message by the carrier-detect interrupt that occurs after the end of any message. Receivers without interrupts or latched carrier-detect pulses must repeatedly wait until a whole character time has gone by without receiving anything. The next field to be received should be the SOT field. If it is not, it will be necessary to go back to the previous step until an SOT is detected.

Once the SOT is detected, the next field should be the Destination Address. When this field is received, it should be compared with the receiver's own address to determine whether the message is intended for this receiver. If your network supports broadcast messages, all

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receivers must check to see if the message is a broadcast message. Additionally, printer and disk storage nodes must also check to see if the destination address is their generic address. If no address match exists, the receiver should go back to hunting for an SOT field (unless this receiver is a gossip monger).

If the message is addressed to a particular receiver, the address and all subsequent bytes should be received and summed together for comparison with the checksum byte at the end of the message. If your particular network uses parity, the message should also be checked for each character received. The receiver should not care what type of message was received; it should simply inform the protocol layer of receipt. With an interrupt-driven receiver, a flag can be set at completion to inform the protocol layer. Additional information, such as whether any errors occurred during the message, could also be communicated to the protocol layer via common memory. If the receiver is not interrupt-driven, this information can be passed back as parameters to the protocol layer.

The Protocol Layer

For the following discussion, *source* will be defined as the node that transmitted the original message, and *destination* as the node to which the message was addressed.

When computer A sends a message to computer B, there is no guarantee that computer B will receive it. Many things could go wrong. There might be a loose connection somewhere. Computer B might not be running, or it might not be listening to the net. Computer C could start transmitting at the same time as computer A.

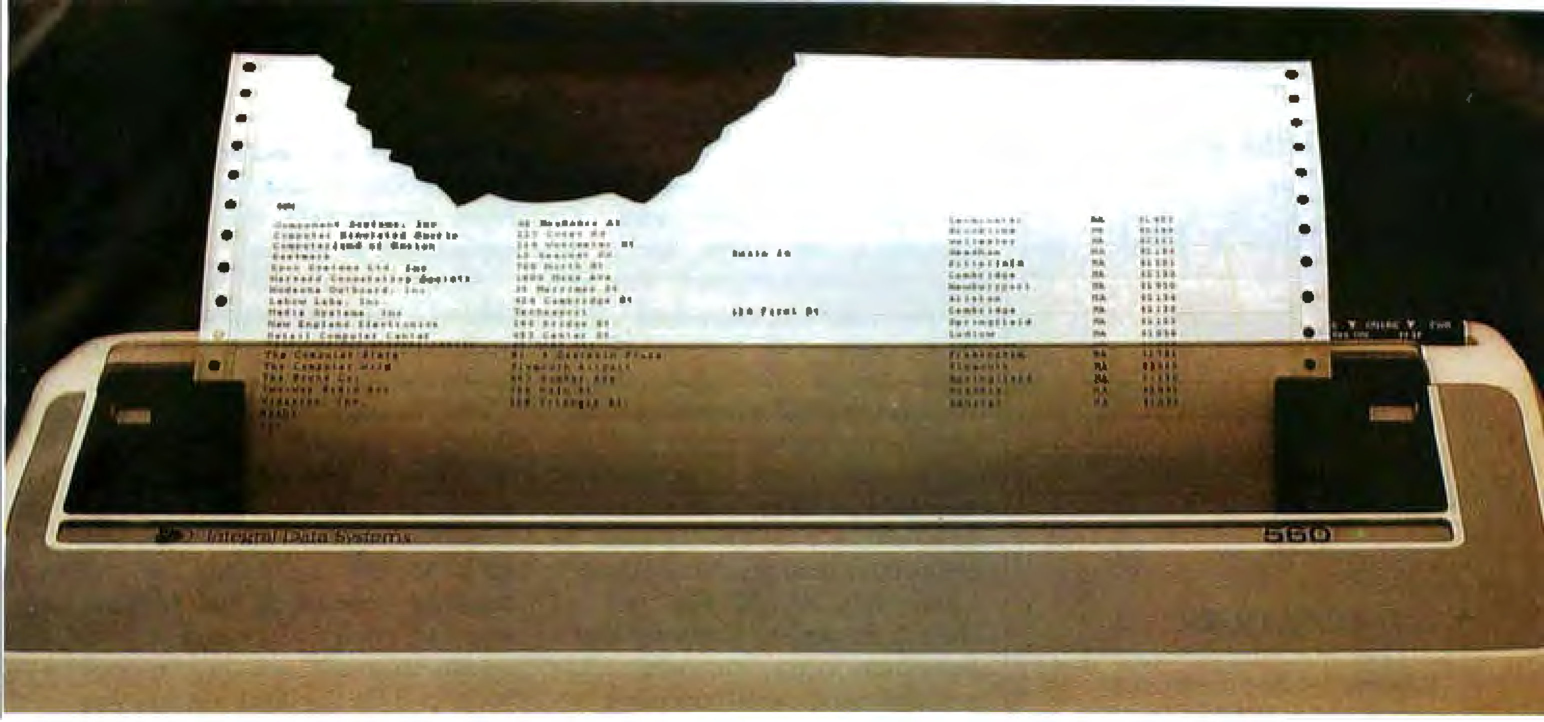
Protocol schemes detect and correct such situations. Protocol is basically a conversation between a source and a destination, trying to ensure that what the source transmitted was actually received by the destination.

The simplest protocol is one in which the source sends a message to a specific destination and assumes the message arrived. If your network is in good working order and you know that a particular destination is running properly, this protocol will be sufficient most of the time. You probably would want to use this protocol, for example, when you are sending messages to your friend Carol, who is using computer B. If she is there, she will probably send a message back, thereby acknowledging that she received your message. You'd also use this protocol for broadcast messages, to prevent the net from getting jammed by everyone trying to send acknowledgments at the same time.

When you are doing things on your net, such as writing a file to a disk, assuming the file got there is not enough. You need some real acknowledgment that the file got to the disk. If no acknowledgment comes back from the destination, or if the destination returns to the source an acknowledgment stating that the disk is full, the source will have to take some error-recovery measures. These are discussed later.

What happens if the destination receives a correct message and sends back an acknowledgment that is not received by the source? In this case, the source thinks its original message did not get through, but it actually did. To avoid this situation, an acknowledgment of an acknowledgment received (ACKACK) can be added to the protocol. If after sending an acknowledgment, the destination does not receive the ACKACK, it will have to take some kind of error-recovery action.

What happens if the source receives the acknowledgment and sends the ACKACK, but the destination does not receive the ACKACK? Somebody has got to have the last word, and there can be no guarantee that a message and all its associated protocol are transmitted and received successfully. Especially on a low-speed network, the criterion for deciding how much protocol to use is "as little as possible for a particular application." An intelligent system might provide all three types of protocol (ie: message, message-ACK, and message-ACK-ACKACK) and allow the application program to decide which one to use.



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Error Recovery

What should be done when a message was sent and no acknowledgment came back? Or when an acknowledgment was sent but no ACKACK came back? Both these cases call for a timing mechanism. A source that transmitted something and is expecting a reply from the destination must wait a certain amount of time for that reply to come back. If the reply does not come back within that time, it will be assumed an error condition exists.

How long should this time be? There is no way to guarantee that a destination really did receive the message and will transmit an acknowledgment within the time the source has set. The waiting time, then, should be more than long enough to cover any reasonable situation.

Once the source has waited a set amount of time without receiving a reply, a reasonable action would be to retransmit the original message at least once more, and again wait the specified amount of time for a reply. The same strategy could be used by the destination when it sends acknowledgments and waits for an ACKACK. If you are doing your network without the aid of a hardware timer, you will need a time-counting subroutine that continually checks to see if a reply was received, and decrements the counter. If the counter reaches 0 before a reply is received, then a *timeout error* exists. If your software has access to a hardware timer, you can use it to set an interrupt.

If no reply is received after repeated attempts to transmit a message, there is nothing to do but give up and report the problem to the program that initiated the network call.

This retransmission scheme introduces another problem. Suppose the source sends a message that is received by the destination, but the destination sends back an acknowledgment that is never received by the source. After timing out, therefore, the source retransmits the original message, and the destination receives it a second time. The Message Number field, along with the From Address field, can be used to correct such situations.

All receivers should keep a list of the last *n* messages received. The list need contain only the message number and the From Address. When a new message is received, the list should be examined for a match. If a duplicate is detected, the message should be "dumped," but the appropriate response should be sent back to the transmitter of the duplicate message. If the duplicate was an original message, an acknowledgment should be sent back, or if the duplicate message was an acnowledgment, an ACKACK should be sent back.

Collisions are another issue. Assuming that all transmitters check the state of the network before starting transmission, collisions can happen only when two or more transmitters start their transmissions within one character time of each other. When collisions happen, all transmitters involved should immediately stop transmitting and allow the network to return to the "not busy" condition.

Now some kind of mechanism is needed to tell colliding transmitters when they can start transmitting again. If they all wait an equal amount of time, they will collide again. Therefore, they must all wait different lengths of time.

One way to ensure this setup is to establish a priority order based on node address. If a node with the address of 1 collides with a node with the address of 3, then node 1 will wait one unit of time before attempting retransmission, while node 3 will wait three units of time. One problem with this scheme is that under heavy load conditions where collisions are more frequent, nodes with high address numbers may never be able to get a message through because they must wait so long after each collision.

A fairer scheme would be one in which each node has a random-number generator guaranteed to create a unique sequence of random numbers. All nodes would then have

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equal priority in retransmissions after collisions.

A Typical Application Program

As an example of a typical application program, let's consider a request to a filing system on a hard-disk node.

The "save" request would first want to send to the filing system a message containing the file name and the number of sectors to be saved. The request probably would ask the protocol layer to expect an acknowledgment and allow the protocol layer to take care of retransmissions if necessary. Along with the acknowledgment would come information from the filing system indicating whether or not the request can be accommodated. If it cannot be accommodated, the request program must report the failure to its caller.

If the request can be accommodated, the save request program must break up the file to be saved into convenient blocks (probably a disk sector). When errors occur during transmission, it is more economical to retransmit small blocks than large ones. In either case, the save request should send an ACKACK to the filing system to say it agrees to what the filing system considers the state of the request.

Once the file has been partitioned into blocks, the save request should hand them in sequence to its protocol layer for transmission to the filing system. The request should ask its protocol layer to expect an acknowledgment for each block transmitted. Each block should have a unique number that can be checked by the filing system against block numbers already received. In this manner, duplicate blocks can be dumped.

By the value of the last block number, both parties know when the file transfer is completed. If implementation is done in a straightforward manner, the last block number should equal the corresponding field in the original request message.

The save request should ask the protocol layer to send an ACKACK to the filing system when it submits the last block for transfer. Upon receipt of this ACKACK, the filing system can be sure it will not be getting a retransmission of the last block, and it can close the file and forget about the request.

When extended conversations are taking place between two nodes on the net (as in the previous file transfer examples), the network can be made to appear constantly busy by never allowing more than a character time to elapse between messages. In this way, no other user on the network can interfere with the conversation.

If the data rate is controlled by software on the two conversing nodes, you might consider increasing the rate after the initial conversational link has been established. The rate could be increased beyond what's normally acceptable to every node on the network, but it must be changed back after the conversation is completed. While the process is going on, every other node on the network should recognize it as a network-error condition. Because the nodes have not seen a transition from a busy net to a nonbusy net, they will not be looking for an SOT field anyway. This scheme can get a little tricky when attempting to end a conversation, especially if the last acknowledgment or ACKACK did not get through but the data rate on one node has already been reduced to its former value.

Multitasking Environments

Networking in multitasking environments raises many issues that cannot be considered here, but a few obvious ones should be pointed out.

The protocol layer probably should be set up as a process by introducing another parameter to indicate whether the application program will "go to sleep" waiting for a reply or acknowledgment. The protocol layer would then have to give the application program a "wake up" by indicating whether the message got through to the receiving process.

Since messages could in this way be addressed to one of several processes on a node, the address fields for To and From addresses would need to be extended to include a Process ID number.

The software design presented in this article reflects only one of many possibilities. For more information, or for software if you don't want to write your own, contact Cheshire Software, POB 2780, Santa Cruz CA 95063.

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Chris Crawford
Atari Inc
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Indirection is a powerful concept in computing, but a difficult one for the beginning programmer to appreciate. In 6502 assembly language, there are three levels of indirection in referring to numbers. The first and most direct level is the immediate addressing mode, in which the number itself is directly stated:

```
LDA #$F4
```

The second level of indirection is reached when the program refers to a memory location that holds the number:

```
LDA $0602
```

The third and highest level of indirection is attained when the program refers to a pair of memory locations that together contain the address of the memory location holding the number. In the 6502, this indirection is complicated by the addition of an index:

```
LDA ($D0),Y
```

Indirection provides a greater degree of generality and power to the programmer. Instead of trucking out the same old numbers every time something needs to be done, the programmer can simply point to them. By changing the pointer, the behavior of the program can be changed. Indirection is an important capability.

Graphics indirection is built into the Atari Personal Computer system in two ways: with color registers and character sets. Programmers using this computer after programming other systems often think in terms of direct colors. A color register is a more complex beast than a color. A color specifies a permanent value. A color register is indirect; it holds any color value. The difference between the two is analogous to the difference between a box-end wrench and a socket wrench. The box-end wrench comes in one size only, but a socket wrench holds almost any size socket. A socket wrench is more flexible, but takes a little more skill to use properly. Similarly, a color register is more flexible than a color, but takes more skill to use effectively.

Color-Register Indirection

The Atari 400/800 has nine color registers; four are for player-missile graphics and will be discussed in a later article in this series. The remaining five are not always used. Depending on the graphics mode used, as few as two registers, or as many as five, will show up on the screen. In BASIC mode 0, only one and one-half registers are used because the hue value of the characters is ignored. Characters take the same hue as playfield register 2, but take their luminance from register 1. The color registers are in CTIA (one of the Atari custom integrated circuits) at hexadecimal addresses D016 through D01A. They are "shadowed" (ie: copied) from certain RAM (random access read/write memory) locations in the Atari OS (operating system) into CTIA during the vertical blank interrupt of the video display. Table 1 gives color-register shadow and hardware addresses.

For most purposes, the user controls the color registers by writing to the shadow locations. There are only two cases in which the programmer writes directly to the CTIA addresses. The first and most common is the display-list interrupt, which will be covered in a later article in this series. The second case arises when the user disables the OS vertical-blank interrupt routines, which move the shadow values from the OS into CTIA.

Colors are encoded in a color register by a simple formula. The upper nybble gives the hue value, which is identical to the second parameter of the BASIC SETCOLOR command. Table 9.3 of the *Atari BASIC*

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Reference Manual lists hue values. The lower nybble in the color register gives the luminance value of the color. It is the same as the third parameter in the BASIC SETCOLOR command. The lowest-order bit of this nybble is not significant. Thus, there are eight luminances for each hue. This gives a total of 128 colors from which to choose (eight luminances times sixteen hues). In this series of articles, the term *color* denotes a hue-luminance combination.

Once a color is encoded into a color register, it is mapped onto the screen by referring to the color register that holds it. In map-display modes that support four color registers, the screen data specify which color register is to be mapped onto the screen. Since there are four color registers, it takes only 2 bits to encode one pixel. Thus, each screen-data byte holds data for four pixels. The value in each pair of bits specifies which color register provides the color for that pixel.

In color-text display modes (BASIC's graphics modes 1 and 2), the selection of color registers is made by the top 2 bits of the character code. This leaves only 6 bits for defining the character, which is why these two modes have only 64 characters available.

Color-register indirection gives the programmer four special capabilities. First, the programmer can choose from 128 different colors for displays.

Second, the programmer can manipulate the color registers in real time to produce pretty effects. The simplest version of this is demonstrated by the following BASIC line:

```
FOR I=0 TO 254 STEP 2:POKE
712,I:NEXT I
```

This line cycles the border color through all possible colors. The effect is quite pleasing and certainly grabs attention. The fundamental technique can be extended in a variety of ways. A special variation of this is to create

Image Controlled	Hardware		Operating System Shadow	
	Label	Hexadecimal Address	Label	Hexadecimal Address
player 0	COLPM0	D012	PCOLR0	2C0
player 1	COLPM1	D013	PCOLR1	2C1
player 2	COLPM2	D014	PCOLR2	2C2
player 3	COLPM3	D015	PCOLR3	2C3
playfield 0	COLPF0	D016	COLOR0	2C4
playfield 1	COLPF1	D017	COLOR1	2C5
playfield 2	COLPF2	D018	COLOR2	2C6
playfield 3	COLPF3	D019	COLOR3	2C7
background	COLBK	D01A	COLOR4	2C8

Table 1: *Names and addresses of color registers used by the Atari 400/800.*

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simple cyclic animation by drawing a figure in four colors, and then cycling the colors through the color registers, rather than redrawing the figure. The program in listing 1 illustrates the idea.

The third application of color registers is to logically key colors to situations. For example, a paged-menu system can be made more understandable by changing the background color or the border color for each page in the menu. Perhaps the screen could flash red when an illegal key is pressed. The use of the color characters available in BASIC graphics modes 1 and 2 can greatly extend the impact of textual material. An account sum could be shown in red if the account is in the red, or black if the account is in the black. Words or phrases of import can be emphasized in special colors. The use of colors in map modes (no text) can also improve the utility of such graphics. A single graphics image (a monster, a boat, or whatever) could be presented in several different colors to represent several versions of the same thing. It costs a great deal of RAM to store an image, but it costs very little to change the color of an existing image. For example, it is much easier to show three different boats by presenting one boat shape in three different colors than three different boat shapes.

The fourth and most important application of color registers is used with display-list interrupts. A single color register can be used to put up to 128 colors onto a single screen. This important capability will be discussed in part 4 of this series.

Character Sets

Graphics indirection is also provided through the redefinable character set. A standard character set is provided in ROM (read-only memory), but there is no reason why this particular character set must be used. The user can create and display any character set desired. There are three steps necessary to use a redefined character set. First, the programmer must define the character set. This is the most time-consuming step. Each character is displayed on the screen on an 8 by 8 grid, which is encoded in memory as an 8-byte table. Table 2 depicts the encoding arrangement.

A full character set has 128 characters in it, each with a normal and inverse video incarnation. Such a character set needs 1024 bytes of space and must start on a 1 K-byte boundary. Character sets for BASIC modes 1 and 2 have only 64 distinct characters. These require only 512 bytes and must start on a ½ K-byte boundary. The first 8 bytes define the zeroth character, the next 8 bytes define the first character, and so on. Each group of 8 bytes is termed a *character definition*; the index that designates such a group (FIRST character, FIFTH character, etc) is called the *character name*. Obviously, defining a new character set is a big job. Fortunately, there are software packages to make this job easier.

Once the character set is defined and placed into RAM, the second step is to tell ANTIC (another custom integrated circuit on the Atari 400/800) where it can find the character set. This is done by poking the page number of the beginning of the character table into hexadecimal location D409 (decimal 54281). The OS shadow location, the location normally used, is called CHBAS and resides at hexadecimal 2F4 (decimal 756). The third step in using character sets is to print the character wanted onto the screen. This can be done directly from BASIC with simple PRINTs or by writing numbers directly into the screen memory.

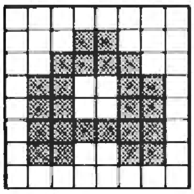
A special capability of the system not supported in BASIC is the four-color, character-set option. BASIC graphics modes 1 and 2 support five colors, but each character in these modes is really a two-color character; each one has a foreground color and a background color. The foreground color can be any of four single colors, but only one color at a time can be shown within a single character. This can be a serious hindrance when using character graphics.

There are two other text modes designed especially for character graphics, ANTIC modes 4 and 5. Each character in these modes is only four pixels wide, but each pixel can have four colors (counting background). The characters are defined like BASIC graphics mode 0 characters, except that each pixel is twice as wide and has 2 bits assigned to it to

Listing 1: *A short graphics program demonstrating the illusion of movement by changing color-register assignments.*

```
10  GRAPHICS 23
20  FOR X=0 TO 39
30  FOR I=0 TO 3
40  COLOR I
50  PLOT 4*X+I,0
60  DRAWTO 4*X+I,95
70  NEXT I
80  NEXT X
90  A=PEEK(712)
100  POKE 712,PEEK(710)
110  POKE 710,PEEK(709)
120  POKE 709,PEEK(708)
130  POKE 708,A
140  GOTO 90
```

CHARACTER IMAGE



BINARY REPRESENTATION	HEXADECIMAL REPRESENTATION
0 0 0 0 0 0 0 0	0 0
0 0 0 1 1 0 0 0	1 8
0 0 1 1 1 1 0 0	3 C
0 1 1 0 0 1 1 0	6 6
0 1 1 0 0 1 1 0	6 6
0 1 1 1 1 1 1 0	7 E
0 1 1 0 0 1 1 0	6 6
0 0 0 0 0 0 0 0	0 0

Table 2: *Internal representation of a character in memory. One character needs 8 bytes to represent it. Although the standard character set is in ROM, the pointer to the beginning of the character set can be changed to point to other memory locations, allowing the user to create a modified or completely new character set.*

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Problem 1:
Write a program to input a list of values (List "A"), sort the list from lowest to highest values, then print all the values in list A in ascending order.

APL/V80 solution:

```
A[⍋A←⎕]
```

Solution in your present language:
(Hint: Usually this takes two loops and 15 to 20 statements.)

Problem 2:
Write a program to input a list of values (List "X") and compute the standard deviation for the list values.

APL/V80 solution:

```
((+/(X-(+/X)÷N)*2)÷N←¯1+⍴X←⎕)*.5
```

Solution in your present language:
(Hint: This takes at least one loop and about 16 statements.)

Problem 3:
Write a program which will compress adjacent spaces to a single space, with possible multiple occurences, in a string of characters called TEXT.

APL/V80 solution:

```
(1,(¯1↓T)∨1↓T←' '=TEXT)/TEXT←⍞
```

Solution in your present language:
?

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specify the color register used. Unlike ANTIC modes 6 and 7 (BASIC modes 1 and 2), color-register selection is not made by the character-name byte, but instead by the defined character set. Each byte in the character table is broken into four bit pairs, each of which selects the color for a pixel. (This is why there are only four horizontal pixels per character.) The highest bit (D7) of the character-name byte modifies the color register used. Color-register selection is made according to table 3.

Using these text modes, multicolored graphics characters can be put onto the screen.

Another interesting ANTIC character mode is the lowercase-descenders mode (ANTIC mode 3). This mode displays ten scan lines per mode line, but since characters use only 8 bytes vertically, the lower two scan lines are normally left empty. If a character in the last quarter of the character set is displayed, the top two scan lines of the character will be left empty. The data that should have been displayed there will be shown on the bottom two lines (see figure 1). This allows the user to create lowercase characters with descenders.

Modified Character Sets

Many interesting and useful application possibilities spring from character-set indirection. The obvious application is the modified font. A different font can give a program a unique appearance. It is possible to have Greek, Cyrillic, or other special character sets. Going one step further, graphics fonts can be created. The Energy Czar computer program

Bit Pair in Character Definition	Color Register Selected D7 = 0	Color Register Selected D7 = 1
00	COLBAK	COLBAK
01	PF0	PF0
10	PF1	PF1
11	PF2	PF3

Table 3: *Use of color registers in character definition during ANTIC graphics modes 4 and 5. See the text for details.*



Photo 1: *A bar chart made using character graphics. Even though each character is eight pixels wide, the horizontal bars can be any number of pixels wide by using redefined characters representing bars of varying width.*



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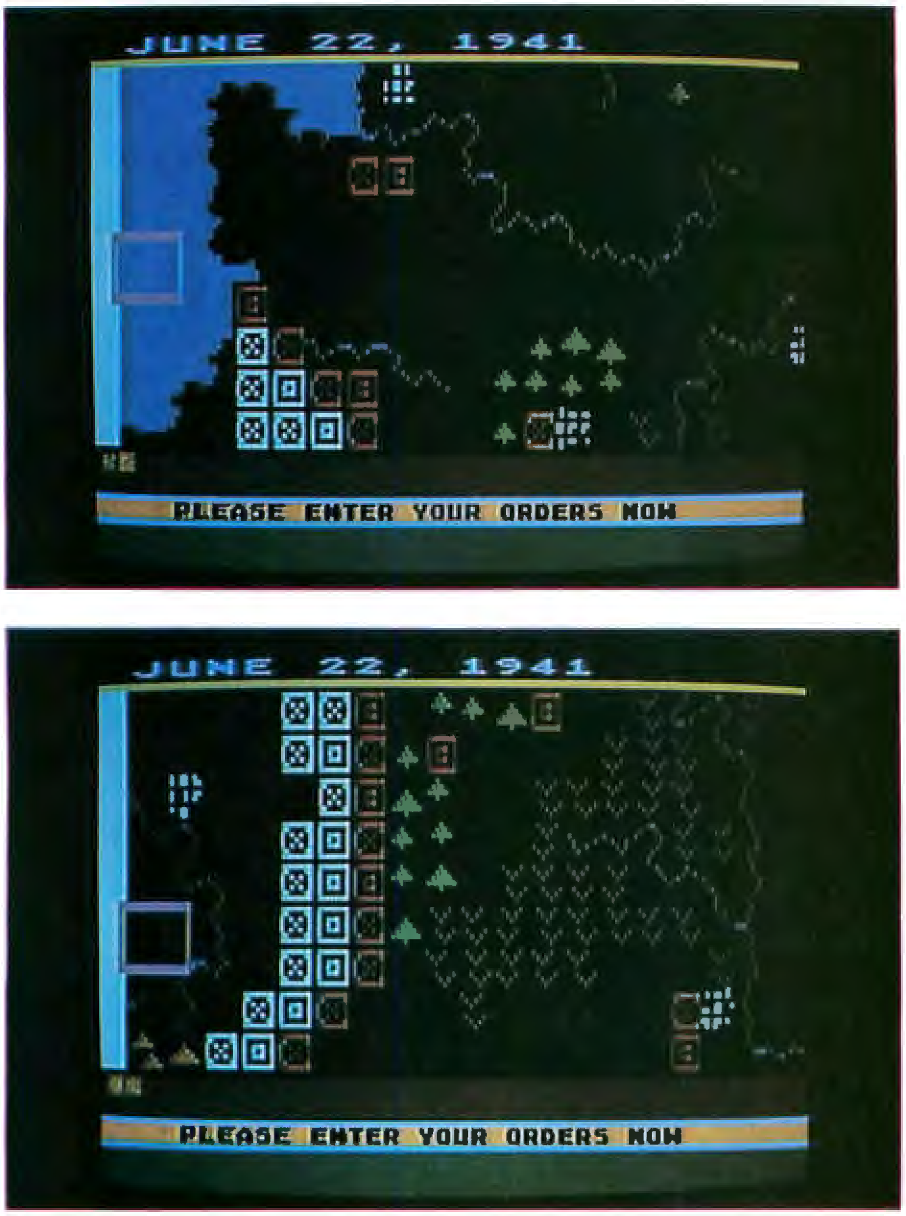


Photo 2: *Two views of a war-game map made totally from character graphics. The map is several times larger than the video display, and a player can use a joystick to view different parts of the map. Even though character-sized graphics are used, the scrolling appears to be smooth due to some advanced Atari display techniques.*

(sold by Atari) uses a redefined character set for bar graphs. A character occupies eight pixels. This means that bar charts implemented with standard characters have a resolution of eight pixels, a rather poor resolution. Energy Czar uses a special character set in which some of the less useful text symbols (ampersands, pound signs, etc) have been replaced with special bar-chart characters. One character is a one-pixel bar, another is a two-pixel bar, and so on to the full eight-pixel bar. The program can thus draw detailed bar charts with resolution of a single pixel. Photo 1 shows a typical display from this program. The mix of text with map graphics is only apparent; the entire display is constructed with characters.

In many applications, character sets can be created that show special images. For example, by defining a terrain graphics character set with river characters, forest characters, mountain characters, and so forth, it is possible to make a terrain map of any country. With imagination, a terrain map of a different planet can just

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as easily be done. When doing this, it is best to define five to eight characters for each terrain type. Each variation of a single type should be positioned slightly differently in the character pixel. By mixing the different characters together, it is possible to avoid the monotonous look characteristic of primitive character graphics. Most people won't realize that the resulting map uses character graphics until they study the map closely. Photo 2 shows two views of a terrain map created with character-set graphics.

You could create an electronics character set with transistor characters, diode characters, wire characters, and so forth to produce an electronics schematics program. Or you could create an architectural character set with doorway characters, wall characters, corner characters, and so on to make an architectural blueprint program.

Characters can be turned upside down by POKEing a 4 into decimal location 755. One possible application of this feature might be for displaying playing cards (as in a blackjack game). The upper half of the card can be shown right-side up; with a display-list interrupt, the characters can be turned upside down for the lower half of the card. This feature might also be useful in displaying images with mirror reflections (reflection pools, lakes, etc).

Even more exciting possibilities spring to mind when it is realized that it is practical to change character sets while the program is running. A character set costs either 512 bytes or 1024 bytes; in either case, it is inexpensive to keep multiple character sets in memory and flip between them during program execution. There are three time regimes for such character-set multiplexing: human slow (more than 1 second), human fast (1/60 second to 1 second), and machine fast (faster than 1/60 second).

Human-slow character-set multiplexing is useful for *change of scenery* work. For example, a space-travel program might use one graphics

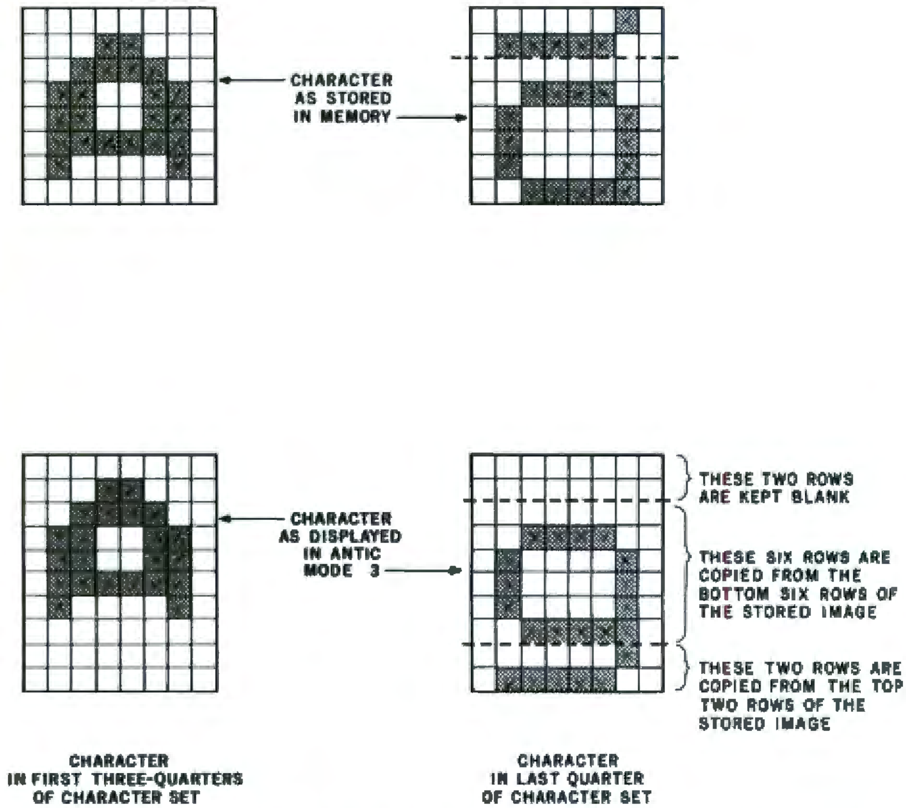


Figure 1: *Lowercase descenders in ANTIC mode 3. Using the method shown here, the Atari 400/800 can display characters in an 8 by 10 matrix, even though their internal representation is an 8 by 8 matrix.*

SuperSoft's Optimizing



for CP/M

The SuperSoft "C" compiler supports most of version 7 Unix standard "C". Several special and widely desired features are supported, including:

- Macro expansions via the **#define** statement.
- Include files using the **#include** statement.
- Inline assembly code is supported with the **#asm** and **#endasm**.
- The object code may be ROMed.
- Programs may be ORGed for any location.
- Completely **dynamic memory allocation** is supported, both by the compiler and in user programs. (That is, the functions 'alloc' and 'free' are provided with the compiler.)

SuperSoft "C" is a two pass compiler. The first pass of the compiler produces an intermediate code (U-code, for Universal code). Pass two contains both the translator and the optimizer. The intermediate code is optimized and assembly code is output to file.

The optimizer typically results in 40% code reduction. This means that compiled object code will run nearly as fast as that which was written in assembler.

An important feature of the compiler is that assembly code is produced. This means that "hand optimization" of critical sections is possible. Also, the inline coder allows easy insertion of assembly language routines.

With the compiler comes the complete source code to the I/O libraries. These libraries are equal to or better than any that exist for the 8080/Z80 computer system. Functions included:

open	close	read	write
seek	tell	fopen	create
putc	getc	flush	

The Seek command supports absolute, relative from front, and relative from end of file. Fopen includes fcreat. Also included with the compiler are numerous sample programs and a complete library of useful functions.

Compile time options include listing file, console output, syntax checking and others.

Requires: 48K CP/M, (more recommended)

"C" compiler:	$200.00
Manual only:	$ 20.00
Z8000 cross-compiler:	$500.00
(CP/M to Z8000 code, requires Z8000 assembler)	
Source code for in-house use only:	$5,000.00

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character set for one planet, another set for space, and a third set for another planet. As the traveler changes locations, the program changes the character set to give exotic new scenery. An adventure-type program might change character sets as the player changes locales.

Human-fast character-set multiplexing is primarily of value for animation. This can be done in two ways: changing characters within a single character set, and changing whole character sets. The Space Invaders game on the Atari 400/800 uses the former technique. The invaders are actually *characters*. By rapidly changing the characters, the programmer was able to animate them. This was easy because there are only six different monsters, each with four different incarnations. High-speed cyclic animation of an entire screen is possible by setting up a number of character sets, drawing the screen image, and then cycling through the character sets. If each character has a slightly different incarnation in each of the character sets, that character will go through an animated sequence as the character sets are changed. In this way, a screen full of objects could be made to cyclically move with a simple loop. Once the character-set data are in place and the screen has been drawn, the code to animate the screen would be this simple:

```
1000  FOR I=1 TO 10
1010  POKE 756,CHARBASE(I)
1020  NEXT I
1030  GOTO 1000
```

Computer-fast character-set animation is used to put multiple character sets onto a single screen. This makes use of the display-list interrupt capability of the computer. This topic will be addressed further in a later article in this series.

The use of character sets for graphics and animation has many advantages and some limitations. The biggest advantage is that it costs little RAM to produce detailed displays. A graphics display using BASIC mode 2 characters (such as the ones in photo 2) can give as much detail and one more color than a BASIC mode 7 display. Yet, the character image will cost 200 bytes, while the map image will cost 4000 bytes. The RAM cost for multiple character sets is only 512 bytes per set, so it is inexpensive to have multiple character sets. Screen manipulations with character graphics are much faster because you have less data to manipulate. However, character graphics are not as flexible as map graphics. You cannot put anything you want anywhere on the screen. This limitation precludes the use of character graphics in some applications. However, many graphics applications remain for which the program need display only a limited number of predefined shapes in fixed locations. In these cases, character graphics provide great utility. ■

This article appears in slightly different form in De Re Atari, *published by Atari, Inc, and is reproduced with its express permission.*

Atari's Telelink I

Glen Flint
14219 Pierce Pl #41
Omaha NE 68144

Telelink I is a program cartridge for the Atari 400 or 800 personal-computer system that lets you access data bases, electronic mail, and other services offered by information utilities such as The Source and Compuserve. You must have the Atari 850 interface module and an Atari 830 modem, or the equivalent, to use Telelink I. One of Atari's printers, Atari 820, Atari 822, or Atari 825, may be used.

Telelink I comes with a well-prepared five-page manual explaining the use of the cartridge. Following a general introduction, the manual explains how to hook up the modem, telephone, and printers. It also describes some of the options for controlling the printers, the width of the screen, and the word or the character mode (which will be explained later). There are lists of what will be transmitted by each of the keys on the keyboard. Some special control-character combinations send ASCII (American Standard Code for Information Interchange) characters not available on the Atari 400 and 800 keyboards. (For example, a Control-[sends a {.) A list of definitions of several data-communications terms is also included. Finally, the manual lists the ASCII character set with the decimal and hexadecimal values of each character. The meanings of the ASCII control characters are also given.

An offer to sign up with Compuserve and receive one hour of free time on Micronet is included when you buy Telelink I. Micronet has several services that may be of interest to the Atari user: one is the monthly Atari newsletter. Another service is a CB (citizen's band) radio simulator. Users can enter the CB simulator and talk with computer users across the country.

At a Glance

Name
Telelink I

Type
Communications utility

Manufacturer
Atari Inc
1346 Bordeaux Dr
Sunnyvale CA 94086
(800) 538-8547; in California
(800) 672-1404

Price
$19.95

Format
Computer program cartridge
(read-only memory)

Language
6502 assembly language

Computer
Atari 400 or 800 computer with an Atari 850 interface module and an Atari 830 modem (or equivalent)

Documentation
5 pages, 8½ by 11 inches

Audience
Individuals wishing to use information utilities and timesharing networks

Control Features

Pressing Control-8 changes the width of the screen from 38 characters to 40 characters. Control-0 toggles between word mode and character mode. The character mode splits words at the edge of the screen; the word mode, which moves a word to the next line rather than splitting it, improves the readability of the text on the screen. This is also known as word wrap.

Atari's printers can be used with Telelink I to provide hard copy of a terminal session. Telelink I reserves a 1.5 K-byte buffer for the printer. This buffer can be printed automatically or under direct user control with the Select key. In the automatic mode, 1 K bytes of data are collected in the buffer, then an ASCII XOFF is transmitted to the sender. (XOFF is an ASCII control character meaning "stop sending data.") At this point, Telelink I stops looking for data from the modem and begins printing the information stored in the buffer. When the buffer





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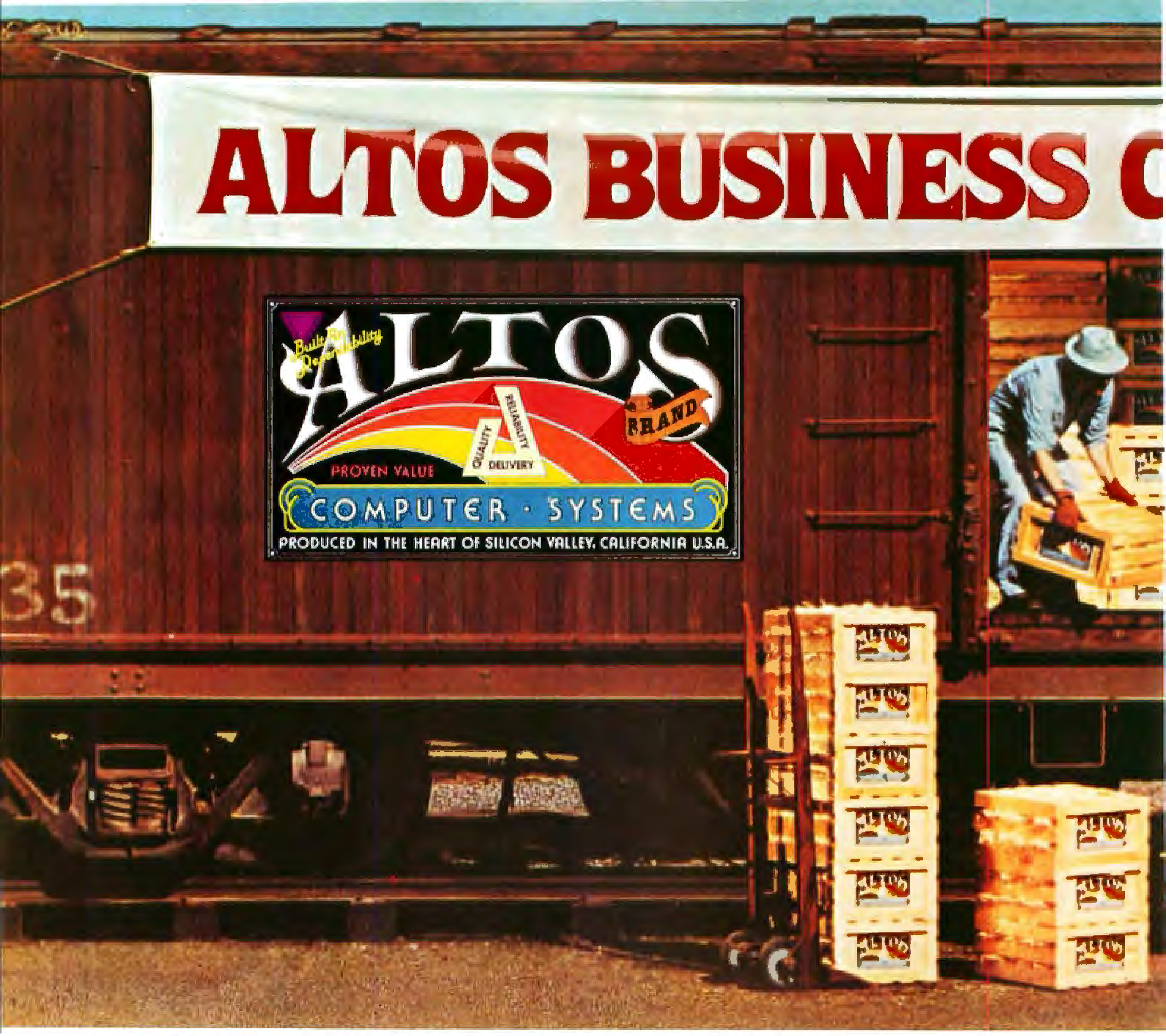
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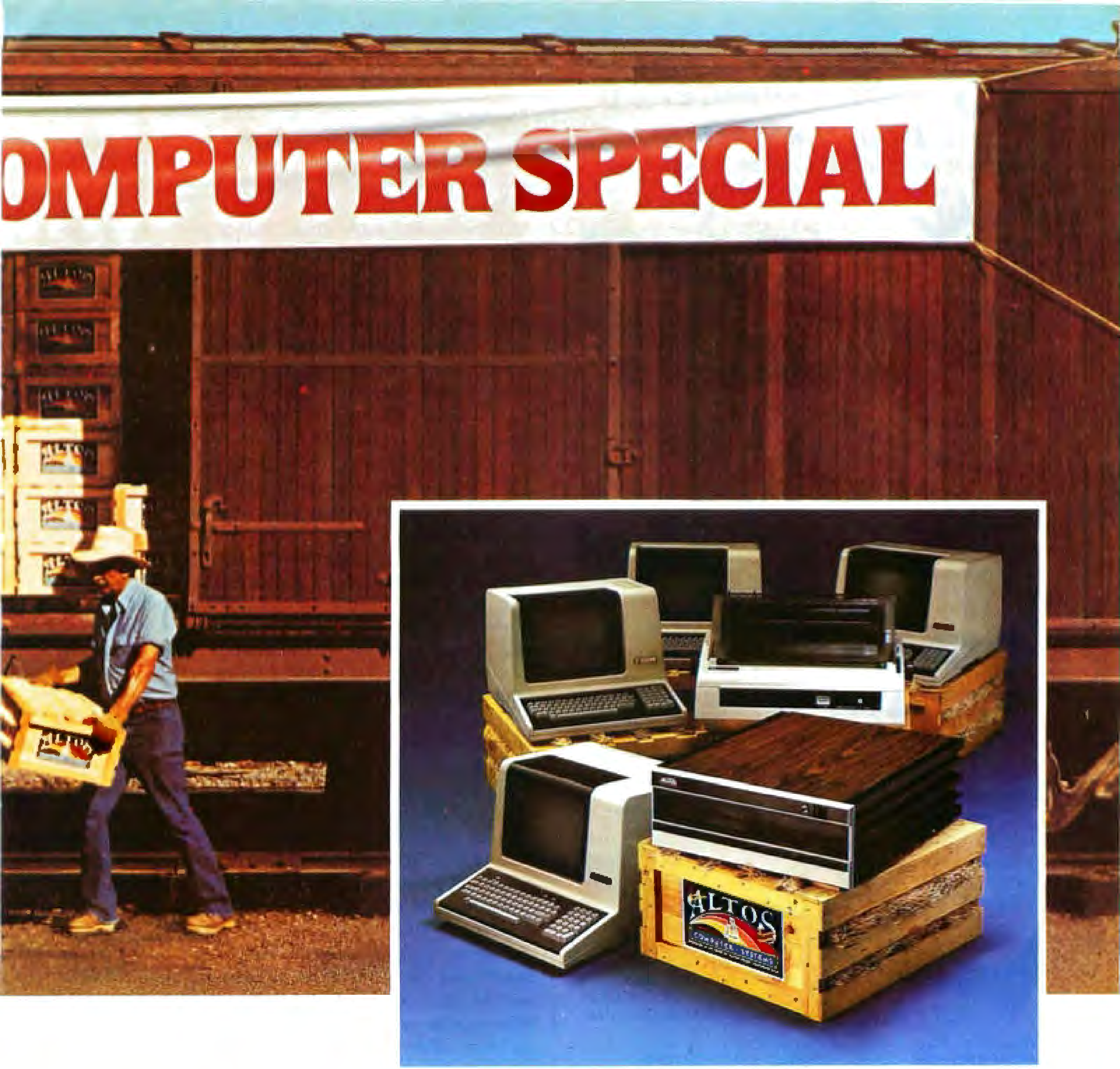


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is empty, Telelink I transmits an XON to the sender. (XON is an ASCII control character meaning "start sending data.") Once the buffer has been filled, this process is repeated. All this is automatic and is handy for copying information to the printer when no user interaction is required.

In the nonautomatic mode, data is received until 1 K bytes of data have been stored in the buffer. At this point, the keyboard begins to make a clicking noise, signaling that the buffer is nearly full. The user must do whatever is required by the communications protocol currently in use to stop the transmission of data. (Due to the serial data transmission on the Atari 400 and 800 peripheral bus, the Atari 850 interface module cannot share the bus with any other peripheral device, including the printer.) To print data, the Atari 850 must not be attempting to transmit or receive data. Telelink I causes the Atari 850 interface to cease monitoring the communication link for incoming data while printing the contents of the buffer. If the transfer of data is not stopped, the data that was received during printing will be lost.

Once the transfer has been stopped, the Select key may be pressed, and the contents of the buffer will be printed. When the contents of the buffer have been printed, the user should send the character(s) required to resume transmission of data. Another buffer will be filled and can be printed by repeating the procedure.

The options provide means to configure Telelink I to your needs. Pressing System Reset will set all of the options back to their default values. Although the automatic printer feature would be convenient, the two networks I tried, Compuserve (through Tymnet) and HDR Systems Inc (in Omaha, Nebraska), didn't respond to the XON and XOFF control characters. The nonautomatic mode will have to be used in cases where the host computer does not recognize XON and XOFF.

When an option is changed, the change is printed on the screen. Perhaps it would have been more helpful to reserve one line of the screen to show *all* the status information continuously. This would make it easy to determine exactly what mode the printer is in at any time. Another helpful feature Atari could have added is the ability to select local echo of keyboard input, rather than depending on the host computer to send back each character it receives.

Conclusions

- The Telelink I cartridge provides an easy way to turn your Atari 400 or 800 computer into a terminal for dialing into information utilities and timesharing networks such as The Source and Compuserve.
- The printer-control features make the cartridge valuable for an Atari system with a printer. The ability to get a hard copy of a terminal session is a definite plus.
- For an Atari system without a printer, the decision may be harder. A simple program to emulate a terminal using GET and PUT (in Atari BASIC) was given in the February 1981 *Compute*. The word mode is a nice feature and probably makes the cartridge worth the extra expense.■



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Local-Area Networks

Possibilities for Personal Computers

Dr Harry J Saal
Nestar Systems Inc
2585 E Bayshore Rd
Palo Alto CA 94303

Today's technical press is filled with announcements of "local-area network" products and "personal computers." New technologies from billion-dollar corporations are being rivaled by products from small firms, in a field no more than a few years old. This article provides an overview of local-area networks and how they relate to personal computers.

Defining local-area network is every bit as difficult as defining personal computer. Features, prices, and technology are distributed across a broad spectrum. Thus, we will try to describe the distinguishing characteristics of a local-area network—how to know one when you see one—and discuss some related system designs that are not local networks, but address many of the same requirements.

Personal Computers and the Group

The revolution in computer systems began with dramatic advances in silicon technology that greatly reduced the cost of the "computing" part of a computer system. Before this, CPU (central processing unit) cycles were a valuable and scarce resource; whole industries grew up developing hardware and software techniques to squeeze out the last bits of efficiency from big mainframes. Learned papers on how to salvage another two percent of processing time dominated computer conferences. People gathered in computer centers (hospital-like environments with air conditioning, raised white floors, and observation galleries). Then, suddenly, all that changed.

The cost of the CPU is no longer the dominant concern. Instead, electromechanical devices such as disks, printers, terminals, and cables generally cost more than the entire central processor. As the prices of these peripheral components drop, the time people spend using the systems becomes more important. We need rapid access to information; we need to review alternatives "online" to make decisions quickly. Our computer systems must respond to our needs and schedules, not the other way around.

The personal computer is dedicated to providing this environment. It is ready for work when we want to use it. It is typically dedicated to one person (or task) and not shared with other people. Although timesharing systems attempted to give the user the illusion of a dedicated computer, they failed because inevitably the load presented by numerous users slowed them down. A personal computer, on the other hand, responds equally well at any time of day. We no longer need to worry about the "wasted cycles" if we simply leave it on our desks just blinking its cursor. The hallmark of the personal computer is this "one person, one computer" approach.

While having to share a central processor may not be justified for many of today's computing needs, information sharing is as important as ever. Once two or more people begin to work cooperatively, they need to communicate and exchange information, whether the impetus be the joint development of a large program, several people checking on information in a common data base, or the implementation of an electronic mail system.

Sharing of larger and more reliable peripheral devices is equally important in all but the smallest computer applications. We can't all have our own letter-quality printer in our office, though we may need access to one. Large libraries of programs or extensive data bases require larger disks than those normally connected to personal computers. Their cost (and reliability) is much higher than

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- conversational mode
- send files
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Multiuser Systems

Personal computer networks preserve the independence of each computer work station while offering the possibility of sharing information and devices among the individuals on the network. Networks are useful in almost all situations where several people need to work together and share information, but still want the attractive features of the dedicated personal computer.

Of course, we can satisfy the multiuser requirements in a more traditional way, too. A number of companies offer shared multiuser systems based on a single microprocessor. Digital Research's MP/M system permits up to sixteen users to share a common microprocessor and its peripherals. MP/M is a derivative of the popular CP/M operating system that permits applications written for that environment to function for multiple users. Onyx's C8000 is a multiuser system based on the Zilog Z8000 microprocessor running the Western Electric UNIX operating system.

Multiuser systems are fundamentally similar to timesharing systems of the past. Users may be happy with the performance as long as the demands on the single processor are low, but they share one of the great weaknesses of central computer systems in that if the processor should fail, everyone loses his work and has to wait until the system is repaired or restarted. And because of the statistical nature of the sharing of the processor, things we take for granted in personal computers, such as real-time graphics and instantaneous response to keystrokes, are sacrificed.

Networks, Networks, Networks

Until five years ago, a computer-communications network generally meant a connection of a large number of terminals, geographically distributed throughout a company or across the country, to one or more central computers.

Anyone using The Source or Compuserve (Micronet) uses such a network. The terminal is connected by telephone to a nearby communications processor, which takes the fairly low-speed information (30 to 120 characters per second) going to or from your home and merges it with the data of other local users. These communications processors are connected together by much higher speed lines from city to city. The data are put into groups, called *packets*, with routing information and error-detecting fields appended, and sent from site to site until the packets arrive at a processor connected to a large timesharing system. (Western Union's Telex and TWX services are other examples of international low-speed networks.) These networks process information at speeds appropriate for humans typing or reading data from a screen. Loading a 16 K-byte program or operating system takes over nine minutes at 300 bps (bits per second); the same load would take under one second from a local floppy disk.

Some networks are used to connect computers rather than terminals. They run at much higher speeds and transmit large files, documents, and electronic mail between systems. But even these nets don't have the bandwidth required to allow modern storage devices to operate at full speed, and are not acceptable for the interactive transmission of program and data files in real time.

Device Sharing

There are a number of systems on the market that permit each user to have his own dedicated computer and share disks or printers, but which are not truly computer networks. Several recent products permit numerous independent microprocessor boards and separate memory to be installed in one chassis. One of these boards is generally reserved for shared access to one central disk subsystem or printer. A terminal is attached to each processor, so each user on the system actually has a dedicated microprocessor.

Such a system is quite attractive, but certain inherent disadvantages still remain. The chassis is large, needs a big power supply and large

cooling capacity, and if any module fails, the entire system, generally, is down. There is no way to add more stations while the system is running, and the terminals can't be located very far from the main processor unit. Each processor must communicate with the others through the common-service processor. They cannot directly exchange information, nor can they have their own private disks, printers, modems, and the like.

Another product for multiuser, independent-processor sharing of a disk is the *disk multiplexer* (the Corvus Constellation is an example). A disk multiplexer can be likened to a very fast rotary switch that cycles around looking to see if any of the computers connected to it wish to do a disk access. When it finds a request, it reads or writes the particular disk sector and then goes on to the next station. The disk multiplexer approach is quite simple and can be an inexpensive solution for many applications. However, due to the very low level of the requests that are typically presented to the multiplexer (eg: read a sector and write a sector) it is generally limited in dealing with the more sophisticated problems that arise in multiuser interactions.

A more sophisticated interface with a powerful software base is needed for complex applications. Like the multiprocessor systems previously described, there is no way for separate stations to communicate directly. They must send their information to the multiplexer, where it goes to disk, or may be temporarily buffered in memory. If the central disk or multiplexer fails, all work comes to a halt.

Networks Without Software

One of the central themes of a computer network is communications. A large number of companies now offer computer networks that provide the ability to transmit data from station to station, but do not address the questions of the necessary operating system, programming language, and applications software needed to make use of these networks. Basically, these units are peripherals with low-level drivers that permit data exchange. While they are suitable for those installations that have the necessary system-programming talent to design, modify, and implement the changes needed to take advantage of this facility, we will be focusing on integrated computer-network systems. Very few vendors are willing to step up to the complex software tasks inherent in blending these technologies into a coherent system design.

Both Digital Research and 3COM provide software without a network. Digital Research's CP/NET system permits up to sixteen stations on a host. These stations share the data and devices on that central host. CP/NET is written without any particular network communication devices in mind. Each hardware vendor may select a particular technology and protocol to connect the work stations to the host. But although CP/NET provides a framework for multiuser software based on the familiar CP/M environment, due to the lack of support for applications in the languages and systems running under CP/NET, many companies have chosen to develop their own variant of CP/M with their own sharing protocols.

3COM's UNET is a package written for the UNIX environment. It is a software implementation of a government-standard intercomputer protocol, called TCP; it, too, leaves open the question of how the computers are actually connected, and application programs must explicitly deal with the network in a nontransparent fashion.

Attributes of a Local Network

A local-area network can be described as a communications network that covers a limited geographical area. Just what "limited" means varies substantially, from 0.1 km (approximately 328 feet) to 10 km (approximately 6.2 miles). Data rates on

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a local network also vary over orders of magnitude, from 100 K bps to 10 M bps, and higher. But these boundaries are far from sufficient to characterize the meaning of "local network" today.

Compared to terminal-like devices, a local network generally has an inexpensive communications medium and high data rates. Every node on the network can communicate with every other node, and the network requires no central node or processor. Messages are "broadcast" over the communications medium, with a destination address included. Only the intended receiver is expected to respond, although other stations have the capability of "listening in." Thus, a high level of security, such as found in point-to-point networks, is not present unless cryptographic techniques are used. Local networks are meant to be highly reliable, so that any failing station will simply be unavailable, without interrupting the communications between the remaining stations. Similarly, it is possible to add new stations without disrupting the ongoing communications flow.

Due to the limited-distance nature of local networks, another standard feature is the ability to connect multiple networks. This internetwork link, called a *gateway*, may be a high-speed link for networks that are close to each other, or it may depend on a more conventional telecommunications network for reliably transmitting data from city to city, or around the world. Because of the multiplicity of emerging network technology, and the variety of communications protocols in use, gateways must be provided to permit stations on one type of network to exchange information with others on a different type or speed of network. Both electrical and software protocols must be converted when passing data through these gateways.

Origins of Local-Area Networks

Local-area networks evolved from the large-scale telecommunications networks developed in the 1960s. As universities and research labs began to install computers, the need arose to permit the flow of information among them. The underlying communications protocols (packet transmission) came from the long-distance networks. The communications media (twisted pair or coaxial cable) were developed to support very high speed direct coupling between computers.

One experiment significantly affected the nature of modern local-area networks: the University of Hawaii wanted to connect terminals all over the Hawaiian islands to a local computer and communications processor, and from there to other networks. They developed a system called ALOHA, a packet radio-transmission system. No wires were used to connect each station to the others, so techniques such as polling could not be used.

The scheme was elegant, and operated in a manner very similar to the way that telephone party lines work. Each station would first listen to see if anyone else was transmitting (in radio jargon, this was called "carrier sense"). If not, the station would transmit its message, including error-detection bits. As long as the total fraction of available transmission time used was low, everyone got a turn—eventually. If two stations found the channel clear and started transmitting simultaneously, the two packets would *collide*. This collision would scramble the information, but the error-detection logic would throw away the bad data. If the stations didn't receive an acknowledgment by a certain time, they would simply send the packet again.

Studies of this scheme quickly revealed a number of problems, one of the more serious being that as the number of messages grew, many collided, and only a small fraction of the true communications bandwidth was used for valid data. Far more serious was the fact that if enough stations tried to transmit, less and less data got through, and the result was continuous collisions!

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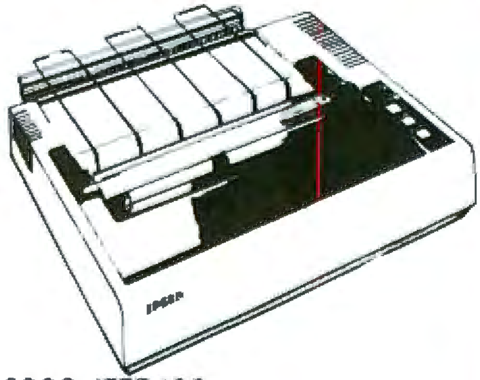
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ALOHA scheme were developed, but the most significant were developed at the Xerox Palo Alto Research Center as part of an experimental project, called Ethernet, started in the mid 1970s. (It was once thought that a universal medium called "luminiferous ether" was the carrier of electromagnetic waves. Xerox decided to build its "ether" out of coaxial cable.)

The Ethernet scheme could detect a collision in progress by reading back the state of the cable *as data were being transmitted*. Thus, a station could sense when another station was sending data and stop transmitting, instead of continuing until the end of its packet. (To guarantee that all such stations recognized the collision, a burst of noise was sent prior to quitting.) A randomized delay function was added so that each station would wait a different amount of time, instead of beginning to transmit immediately after a previous transmission was complete. This avoided causing a collision each time two or more stations had something to send. The delays would get progressively longer as the channel became busier.

Using these modifications, an Ethernet-style local network could use essentially all the bandwidth of the communication medium. Even as stations began sending ten times as much information as the channel could handle, things no longer came to a halt.

The Ethernet algorithms were designed to be simple. Every station on the network manages its use independently, so there is no need for a master to control access. Simplicity was important to ensure minimal building costs and reliability. Other schemes are considerably more complex, which makes them either difficult or expensive to include in each node's interface.

Network Topology

Most early local networks used a *star* topology (see figure 1): a central node was connected via a radial cable to each of the other stations. Unfortunately, this system suffers from the consequences of a central failure. The entire system goes down if the center fails. But there are still many reasons to use a star network. Telephone exchanges are organized as star networks, and many companies already have PBXs (private-branch exchanges). By using the PBX as a local-area network for data as well as voice communication, companies can take advantage of the already existing wiring: this is most suitable for low-data-rate information, such as video terminals.

A *ring* (or *loop*) topology connects its stations in a closed network. Messages circulate in one direction, often being amplified and repeated at each node they pass through. Again, a station failure can interrupt the entire message flow, but in some cases two alternate parallel loops are provided for reasons of reliability. Rings often use a form of control strategy called a *token*. A token is a special message that gives the receiving station permission to transmit. When a free token comes by a station that wants to transmit, the token is removed and replaced by the message. Generally, the same station removes this message when it comes around again and reinserts the token.

Rings are most popular in process-control applications (eg: controlling equipment in manufacturing environments). When dealing with the equipment being controlled, it is important to be able to guarantee the worst-case maximum time necessary to send a message to some station, say to close a valve. Token systems can provide a solution to this problem. The random nature of the Ethernet scheme might prevent a station from sending a critical message in time. (Actually this is a bit misleading. Ethernet can be used to build token-like control that requires stations to avoid sending a message just because they see the net is free; they have to wait to receive the control token first.)

Much of the ring approach has been developed in England, particularly at Cambridge University, where numerous computers and terminals have been interconnected using a simple but high-speed interface. Several British companies are now developing commercial versions of the Cambridge Ring interface unit.

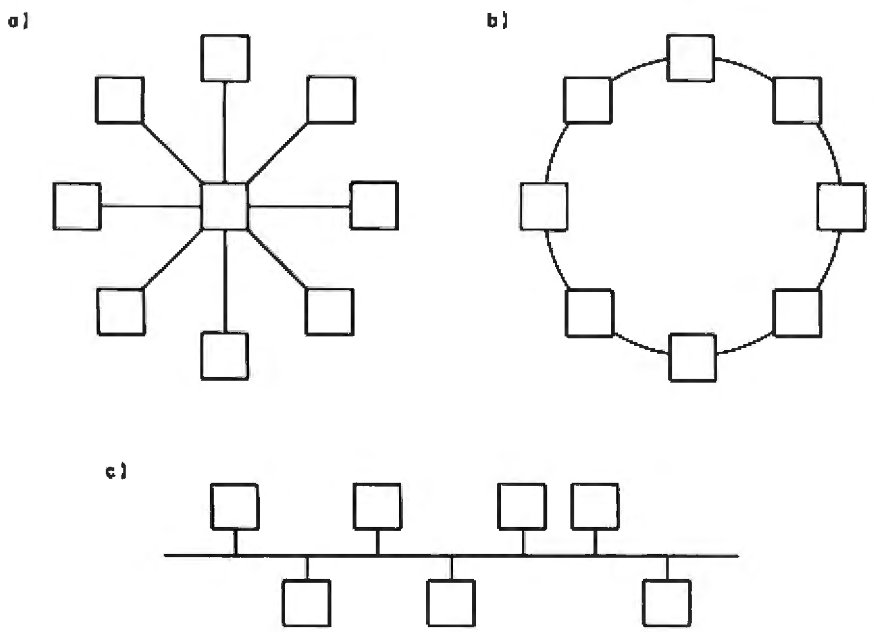


Figure 1: *Popular network topologies. The star network (1a) is the most common of the early network types (such as the telephone system), and relies on the central node for control of operations. The ring network (1b) circulates all messages in one direction, and may employ tokens to specify which node may transmit; a failure of any node may interrupt network operation. Bus configuration (1c), as used on the Ethernet and by cable television, allows nodes to be added or removed without impairing the network.*

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Bus topology is quite simple, being merely a long length of cable that runs past each station. Stations are connected to it at the nearest point, and can be added or removed without affecting any other station. A station can be added in two ways: the bus can be split, temporarily disrupting communications, and a new station inserted, or, more commonly, *taps* (devices developed by the cable TV industry that literally pierce the cable from the outside, making contact to the inner conductor and the outer shield) can be installed while stations are transmitting. Even temporary shorts will only garble some packets, and they will be retransmitted once the short is removed. The Ethernet uses this form of interconnection.

What Frequency, What Wire?

Another significant parameter in the description of a local-area network is the particular medium used to send the information between stations. Local networks have used twisted pair, multiconductor flat cable, coaxial cable, optical fibers, and even infrared light transmitted through the atmosphere. Within each of these categories, numerous choices abound in the frequency used for transmission and the details of the modulation technique.

The most fundamental split in technology revolves around frequencies used on coaxial cable. You can think of coaxial cable as a simple wire. If someone wants to send information, the wire can be left at 0 V or raised to some nonzero voltage. Another station can detect the changes in voltage and decode the information. This is generally referred to as *baseband transmission*, since the frequency spectrum generated starts at 0 Hz (direct current) and goes up from there.

Television transmission is sent at very high frequencies (typically 50 MHz to 100 MHz). A central carrier-frequency is modulated up and down to transmit the information. At these frequencies, the cable has far less attenuation than in the baseband region, so a transmitter can broadcast over miles of cable instead of being limited to several thousand feet. And the blossoming cable-TV industry can provide the necessary devices at a very low cost due to the large volumes they are expected to produce for standard television reception. RF (radio-frequency)-modulated systems can also provide much higher bandwidths than baseband, so the cable can, in principle, be shared along with voice- and video-transmission systems.

RF systems (also known as *broadband*), while very attractive, do require a central retransmitter to receive the data sent from each station and rebroadcast it, much amplified, at a different frequency that each station is expected to listen on. The required unit is expensive, even for the smallest system, and if that unit fails, the network is unavailable until the retransmitter is back in service.

Local-Area Network Standards

Numerous local-area network products have already been announced, and new entries are made daily. In almost every case, the manufacturers have developed their own hardware and software protocols. These, naturally, are incompatible with everyone else's!

The exception to the above incompatibility is the Ethernet specification released in November 1980 by DEC (Digital Equipment Corporation), Intel, and Xerox Corporation. Based on years of actual experience with an experimental version of Ethernet communications, the "tri-company standard" was provided, with every detail of the electrical and low-level communications protocols defined. These companies are trying to encourage the adoption of this scheme among computer and peripheral manufacturers; indeed, many large and small companies have publicly announced their adoption of the DIX Ethernet system, and are busy designing and building products.

The DIX Ethernet system uses a baseband-transmission scheme, with a 10 Mbps data rate. It provides for the use of a large number of stations and packet formats, with 48 bits allocated for a unique world-wide

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station address that is not duplicated anywhere, and it has a large (32-bit) checksum on each packet to detect errors.

This scheme pushes the technological requirements by operating at such high speeds and using the particular packet format and checksums adopted. Without specially designed VLSI (very large scale integration) devices to handle the network interface, it is expensive to build an Ethernet interface. For example, Intel has announced a Multibus Ethernet interface (the iSBC-550) that costs about $4000. To that you must add several hundred dollars for an analog interface (the transceiver unit) to connect between the interface board and the physical cable. It is expected that volume production of the needed components will begin within the next two years and prices will drop dramatically.

One means of lowering the effective cost is to share the Ethernet interface among several stations. A number of companies (such as Xerox, and Ungermann-Bass) offer a microcomputer-based Ethernet interface with four to eight ports for connecting terminals or other microcomputers. The effective cost per station can be reduced to between $500 and $1000 for a fully loaded system.

Standards Organizations

While product activity continues, several committees are attempting to develop an industry-wide standard for local-area networks. The IEEE (Institute of Electrical and Electronics Engineers) Computer Society Local-Network Committee (Project 802) has been meeting for over a year to try to establish a viable standard, and the standard is still in a state of flux. Fierce battles have been raging among the committee members representing different local-network interests. The IEEE standard has been evolving in a manner that attempts to accommodate many diverse application areas and functional requirements.

The framework for defining a communications network is based on a highly layered series of protocols developed by the ISO (International Standards Organization), called the OSI (Open System Interconnection) protocols. The OSI architecture defines seven layers of communications.

Layer 7, the Application layer, provides for the identification of users and services, and is responsible for initiation and reliability of data transfers, as well as general network access, flow control and recovery. Utility programs may perform network file-transfers, terminal-to-network support, etc.

Layer 6, the Presentation layer, is primarily responsible for making data available to the Application layer in a meaningful fashion. The Presentation layer takes care of protocol conversion, data unpacking, translation, or encryption.

Layer 5, the Session layer, is used to set up and break communications paths across the network and manage the exchange of data. It is responsible for multiplexing and demultiplexing

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messages, managing the sequencing and priority of these messages, and providing the needed buffers.

Layer 4, the Transport layer, provides another level of connections between network entities. This layer manages the connections and segments messages into smaller pieces that the network can support. It may also be involved in error and flow control, as well as additional multiplexing activities.

Layer 3, the Network layer, is the level that actually determines how to get a message from one network to another (since many paths may exist). The Network level may use several intermediate hops to get information to its ultimate destination and, thus, needs to know how to route packets through the network. It, too, may be involved in sequencing and error- and flow-control activities.

Layer 2, the Data-Link layer, is where the actual packet formats are established, along with the particular access control mechanism used to regulate use of the physical network. Data is encapsulated in packets that contain physical addressing information, error-detecting checksums, etc.

Layer 1, the Physical layer, defines the electrical and mechanical interfaces to the network. The Physical layer specifies the particular signaling means (baseband vs RF, for instance), the modulation technique adopted, station-identification addresses, etc.

The current activity of the IEEE 802 committee is focused on specifying Layers 1 and 2, the Link and Physical levels. Similarly, the DEC/Intel/Xerox Ethernet specification addresses only these two levels of protocol.

It appears that the 802 Committee is converging on a standard that offers many alternatives within one framework. Even the issue of data rate (specified by Ethernet as 10 M bps) appears to be an optional value (such as 1, 5, 10, or 20 M bps). The error detection used may be either a 16- or 32-bit CRC (cyclic redundancy check) code, and the access method may be either a token-like scheme or a CSMA/CD (carrier-sense, multiple access with collision detect) scheme resembling (but not identical to) the Ethernet system. While the 802 Committee deliberates, manufacturers continue to develop their own systems. It is possible that some may modify their products once standards activities are resolved.

Recently, attention has been given to the higher levels of protocols. The National Bureau of Standards is proposing a series of Transport and higher-level protocols. It is unfortunate that the work on the higher-level protocols does not precede the lowest-level issues. The advantage of layered protocols is that the underlying levels can be changed in ways transparent to the higher levels, while the converse is not true, but the standards activities are not moving in that direction.

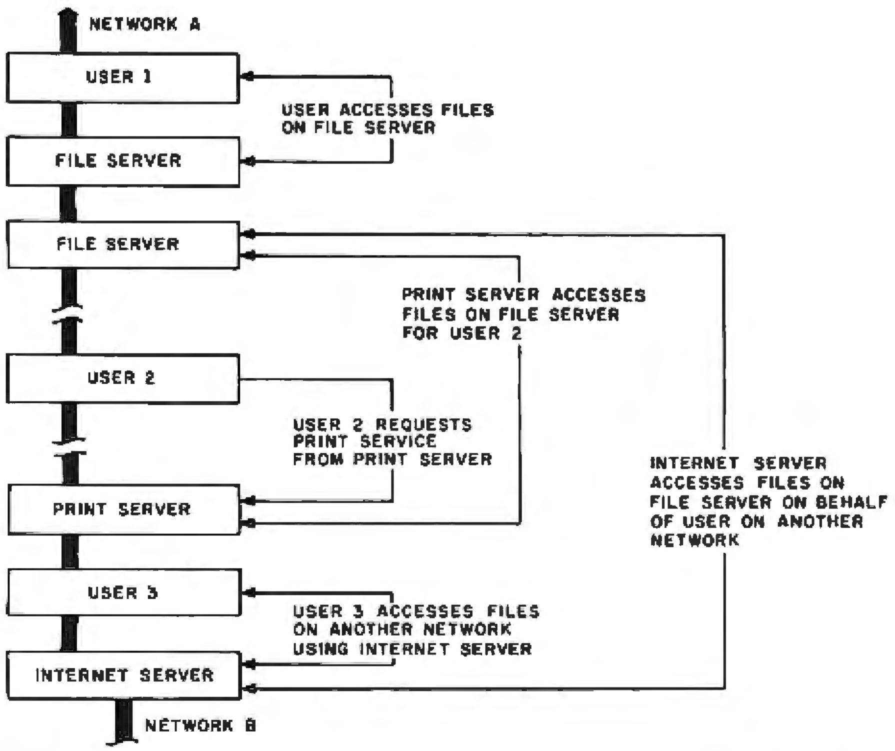


Figure 2: *The server/client relationship on local networks. Perhaps the most significant advance in communications is that, under this scheme, the computer system is fully distributed; there is no master node, so each node can call on others when resources are needed. Some nodes are dedicated to special functions, such as controlling hard-disk mass-storage devices, or printing.*

Servers and Clients

The most significant contribution in the local-area network field is not the communications aspect, but the development of a whole new way of building computer systems. The fundamental organization described by Xerox assumes a fully distributed control mechanism (see figure 2). There is no master-slave relationship among stations; they all communicate and cooperate with one another. Any number of stations (called *servers*) on a local network may provide services to other stations (called *clients*). Typical server functions are: mass-storage file system, printer support, time-of-day clock, translation of symbolic names into physical addresses, data-base management support, gateways to other networks or computers, and other specialized hardware support. Servers may also be clients of other servers on the network. For instance, the printer server may be a client of the file-system server in the course of serving its own clients.

Servers are distinguished on the network merely by the software they run and any special hardware they contain. A station that is willing to listen to requests from other stations (using a higher-level protocol they

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agree on) can perform a server function.

In order to maintain a high level of reliability, the logical functions of the servers are usually implemented using separate physical computers. One could merge all of the above services into one larger computer, but in doing so would end up with something resembling a conventional central computer system.

Putting It All Together

Clearly, the local-area network field is too broad to cover in great depth. Most of the attention has focused on nonpersonal computer systems, such as large mainframes or terminals. We will describe the Nestar Cluster/One Model A system.

The Cluster/One Model A is a local-area network system based on the Ethernet principles, but its implementation has been optimized for the connection of low-cost Apple II personal computers. The system was first announced in January 1980 and has been used around the world for almost two years. It includes integrated software and hardware features needed to provide a comprehensive data-processing and data-communications facility, and the system permits either independent operation of individual stations, with a full complement of local peripherals, or a share in the larger, more reliable peripherals via the local network. The work station in question costs between $1000 and $2000, so cost constraints differ from those applied to networking work stations in the $10,000 to $20,000 price range. Nestar chose to implement many network functions via simple programmable hardware, and assigned many functions to software. Another decision influenced by these cost factors involves network speed. The speed of the Cluster/One was decided by the reasonable cost for a personal computer network interface and the bandwidth requirements needed for the work typically done by these personal computer work stations.

The Model A network operates at 240 kbps—almost a thousand times faster than a 300-bps telephone link, and 40 times slower than the Xerox Ethernet system. This was the fastest rate that could be supported by network-interface software running on the 6502 host processor of the Apple II computer and still allow data checksums to be performed on the message packets.

The choice of the network medium was also influenced by the basic cost goal. Rather than taking 8-bit data from the Apple memory and then serializing and deserializing it, it was decided to transmit the data in an 8-bit-wide parallel fashion, which not only reduced the interface cost, but increased the inter-bit transition time. This has the effect of permitting essentially arbitrary interconnection topology for the Nestar network, something not found in any other system. The Nestar network is not restricted to a linear-bus topology, but can be wired as suits the particular installation requirements.

Network Design

The overall system design resembles the Ethernet scheme. No single critical component must function for network communication to take place. All station-to-station communication is direct, with a carrier-sense algorithm executing in the ROM- (read-only memory) based protocols in each station interface. The interface is passive, so stations may be added or removed from the network during operation. Stations not in use may be turned off until needed.

In the Model A network, the carrier-detect function is implemented using a dedicated control line, which indicates the bus is busy. Stations do not transmit until they see that this line is available. The electronics of the bus interface permit reading of data just written. However, it is not necessary to perform full collision detection. At the start of a packet transmission the address of the station attempting to send is first put on the bus, and then read back. If two stations do this simultaneously, at least one will not read back its own address and will detect a conflict. Even this is rare, since each station has a random waiting algorithm that avoids most collisions that would occur at the end of a previous transmission. Once this initial collision detection has been passed, the carrier signal has been established and further collision detection is not necessary. The rest of the packet is sent, like ALOHA, without collision detection. After the initial check, later collisions can result only from erroneous stations, and not under normal conditions.

Each packet of data contains initial header information, followed by up to 256 bytes of data and a 16-bit checksum. Once the packet is transmitted, the receiving station immediately acknowledges the receipt of the packet (if the checksum matches the data) or else requests a retransmission. This error-control algorithm is completely contained in the ROM-based protocols on the Nestar interface, and permits higher levels of software to work with reliable and correctly sequenced data. The ROM protocols are also responsible for taking messages longer than the 256-byte packet size and splitting them into multiple packets, each with its own checksum. Thus the four lowest layers of the OSI protocols are supplied as part of the logic on board the Nestar network interface.

The Model A network also includes a variety of network servers and the software needed to make their use literally transparent to current applications. The Nestar Network File Server runs on an Apple II microcomputer interfaced to the network. It can support a variety of devices, ranging from two 8-inch double-sided floppy disks, to 66 megabytes of hard-disk storage. Larger capacity is available by using more than one file server. The network software allows multiple file servers on one local network, thus giving essentially unlimited online storage capacity. The data on these reliable, sealed Winchester disks can be "backed up" using Nestar's compact cartridge-tape streamer drive. A single cartridge can write and check over 20 megabytes of data in twelve minutes.

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contain a real-time clock/calendar, which stations can interrogate. This facility is used to *timestamp* the creation, access, modification, and backup times of network files. Files are organized with a tree-structured system similar to a UNIX directory; they can be password-protected in a variety of ways to ensure that only authorized users can create, modify, or otherwise access network data.

The software provided makes the use of this data straightforward from any Apple II work station on the network. All of Apple's current operating systems (DOS 3.2, DOS 3.3, Pascal 1.0, and Pascal 1.1) can be directly loaded over the network. Modifications are made during this process so that stations can logically connect to virtual disks on the network shared disks (either from keyboard commands or from programs). These disks need not have the same capacity as 5-inch floppy disks, but may be much larger or smaller. Each storage area is allocated the appropriate size for the application; users may be executing programs in any set of languages or operating systems at the same time.

Network Applications

The Cluster/One network has been used in a variety of applications that include general office-automation environments, engineering and software development sites, educational and entertainment uses, and special turnkey applications, such as travel-agency and real-estate systems.

To support this variety of uses, Nestar provides a number of general-purpose computing products. Other servers, such as print servers supporting a multiplicity of printers, are available. Communications servers support internetwork activity. Application programs for general database access, interoffice electronic mail, and teleconferencing, have been developed by Nestar, either in-house or in conjunction with the suppliers of popular packages for the Apple II. The collection of hardware and software capabilities makes this network attractive for a wide range of application areas.

What's Next?

There seems to be little doubt that the current interest in local-area networks and personal computer work stations will continue to grow over the next few years. As stations become more powerful and sophisticated in both systems software and applications programming, they will replace an even larger fraction of conventional minicomputer systems. As manufacturers provide fully integrated VLSI components designed for very high performance networks, they will be incorporated into the personal computer local-area network interfaces. Whether or not the standards activities will stem the proliferation of de facto standards remains to be seen. The emergence of networks of personal computers has opened up a whole new set of challenges for programmers in developing real-time, multiuser, interactive systems.■

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"When I get my personal computer, I'm going to make it pay for itself. I have some ideas for programs that everyone will want to buy." Such dreams are shared by many prospective microcomputer buyers, some armed with a college programming course, others with experience writing programs for business.

What these aspiring software authors usually don't know is how to prepare a program with the best possible chances of being accepted, published, and marketed. As a result, they enter the highly competitive software market with a disadvantage that may even guarantee failure.

But programmers' pipe dreams can have happy endings. If you want to write software for publication, consider these steps toward success.

Look at the Market

The first step in writing a marketable program is to conduct your own market analysis before choosing your subject. If the market is already cluttered with programs similar to the one you're considering, yours won't stand a chance unless it includes a special feature that will grab the attention of potential buyers.

Games and simulations have enjoyed great popularity since the beginning of the microcomputer age, and they probably always will. But the universe can hold only so many versions of Star Trek, and any microcomputer used for game playing already has at least one. The game is still fun, but the market has worn thin.

Star Trek is only one example of a game that has been programmed to death. Dozens of versions of Nim, Slot Machine, Guess the Number, Dice, and many other games are stacked knee-deep in the marketplace at give-away prices. Chess might be an exception because of its perennial appeal, but a new chess program won't attract attention without a record of strong tournament play. New versions of old games assail software publishers like so many attackers on the video screen. But publishers can make unlimited use of the ultimate weapon: the rejection slip.

Finding a Subject

Adventure games and sword-and-sorcery games are the most popular simulations now. They bring the excitement of storytelling and role playing into computer entertainment.

Games that spring from your own imagination hold more promise than rehashes. Literary classics can also inspire games. Stories like *Gulliver's Travels* and *The Voyages of Sinbad* contain excellent dramatic situations that can serve as the basis for games with wide appeal. So do *1984*, *Animal Farm*, and many romantic classics. Don't overlook game and puzzle books; they often contain the seeds of intriguing situations.

When you choose a game situation, make sure it challenges the player. To offer a challenge, the game must encompass a complex and variable winning strategy for the player. If the winning strategy is fixed, the player will soon discover it, and the game will cease to be fun. Although you can create difficult games by arranging for a high-probability random function to "kill" the player, such games are more frustrating than challenging. The player shouldn't get "killed" in the middle of the game unless he uses faulty strategy or makes some other mistake. If the player plays with care and uses an intelligent strategy, he should win.

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golf, bowl, or play tennis, perhaps you could write a program for computing players' handicaps or for scheduling and managing tournaments. Tournament directors would be a natural market.

Depending on your interests,. you could consider writing programs that manage stock portfolios, catalog stamp collections, or make an inventory of personal property. Other possibilities are programs that record progress in training activities or dieting and then display the data graphically. Hobbies and club activities such as scouting offer dozens of possibilities.

If you have trouble coming up with a good program idea, get some friends together for a brainstorming session. To stimulate everyone's imagination, choose a field in which you feel reasonably competent, then describe in general terms some program that's been thoroughly exploited. Think of a few variations on that program.

The most important thing to remember about brainstorming is never to reject or belittle a suggestion, no matter how trivial or ridiculous it may seem. Don't risk turning off anyone's imagination. Once the session gets rolling, it will have its own momentum. Write down every suggestion, or better still, tape record the session. One brainstorming session with a few intelligent people will yield enough material to keep you busy writing code for years.

Remember the Hardware

When choosing the subject of your program, another thing to keep in mind is the capacity of the computer on which the program will run. The most popular computers obviously offer the biggest market. If at all possible, scale the program for a popular machine.

Once you've selected your subject, you can start writing the program. It's important to write readable code. Readability not only makes the program easier for you to debug, it also endears you to customers who need to adapt the program to their particular systems or tastes.

Not So Fast!

When the program is finished, debugged, and running perfectly, stop! Don't send it to a publisher yet. Now is the time to add those finishing touches that make the difference between a good program and one that is really commercial and marketable.

Study your program with a critical eye. Ask yourself, "Does my program contain all the instructions the user will need?" Make sure the instructions are thorough, clear, correct, and free of misspellings and grammatical errors.

Then ask, "Does my program lead the user through it? Is it conversational and personal?" A game, for example, doesn't pit just any anonymous soul against the villain.

Circle 12 on inquiry card.

The player who faces all the dangers your program holds has a name. Your program should ask the user's name and call him by it frequently.

Now ask, "How does my program treat the user?" Cute messages are okay if used sparingly and in good taste, but never be condescending or insulting to the user. Remember that the user bought your program to perform some task or to have a good time. If he enters a response that isn't in the accepted input range, don't tell him he's an idiot. Tell him what the accepted input range is.

There is nothing so discouraging as running a program and finding yourself facing a prompt without knowing what kind of input is expected, or seeing attackers swarming across the screen when you don't know how you're supposed to defend yourself. If the program doesn't make clear at all times what input it expects, then you owe the user the courtesy of a way to ask for help.

Remember that the user is also your customer. If you treat him with respect, he'll consider buying your next program. These finishing touches are just as important to the program as the most intricate code.

Don't Forget Testing

Is the program ready to go to the publisher now? No, not until it's been tested. Bring in a friend and give him the program to load and run. Don't give him any help. Watch every detail as he works his way through the program. Make notes both for changes in the program and for anything that seems appropriate to put in the user's guide.

If your friend has trouble with the mechanics of the program (not in developing a game strategy), review the game later to see if ambiguous or inadequate instructions caused the problems. If your friend gets hopelessly stuck and you are forced to help him, you must face the fact that you have either a flawed program or a less-than-brilliant friend. You'll probably feel better if you blame the program and go back to work on it.

After correcting problems discovered in the first test run, bring in a different friend and repeat the usability test. This isn't because you're no longer speaking to the first friend, but because you need another naive user. If the second friend can use and enjoy the program, you may be ready to write the documentation. If the second friend has problems, you'll have to revise the program and find a third friend. If you run out of friends, you'll probably find that enemies are better at testing software anyway.

You can't test a program too much. Once you're satisfied that the program is usable, you can begin writing the documentation.

Before you started work on the program, did you write down the things you wanted it to do? If so, you may be able to modify your notes as a starting point for the user's guide. You should also use your notes from all the test runs.

A user's guide should be written in the simplest words possible. Don't try to show off your vocabulary or prove how ingenious you were in writing the program. Invite a friend to read the first draft and offer criticism. Insist that he point out any places where the user's guide is unclear, ambiguous, or overwritten. Don't be upset if the first draft requires extensive changes. After you make the revisions, type or print a fresh copy on good paper. Include a title page, a copyright notice, and a table of contents. Then place the user's guide in a binder that looks good and makes turning the pages easy.

Now Is the Time

Now, finally, you're ready to submit your program to a publisher. The user-friendly program and the professional-looking user's guide will greatly increase the likelihood of acceptance. The user's guide may also provide the basis for advertising copy when your program goes to publication.

Amateurs are writing many of the programs submitted for publication today, and the lack of professionalism often shows. It shows in programs that have bugs, poor instructions, incorrect spelling and grammar, and shoddy or incomplete documentation. Most of all, it shows in the choice of unsalable subject matter.

Take the time and effort to make your program look and perform as if a professional had written it. At the very least, you'll be proud to run the program on your own system. And there's a good chance your effort will pay off in more sales and hard cash.■

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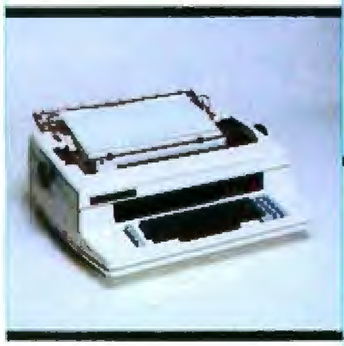
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List Pager

Allan Lovett, 20024 N 18th Dr, Phoenix AZ 85027

List Pager, shown in listing 1, is a simple program for the Apple II or Apple II Plus computer. The program prints out listings, one page at a time, with a title on the first page and a number on each of the following pages. It will not split statements between pages but will instead automatically produce line feeds to move to the next page. You can choose either a full 80-column format or 60 columns with margins on each side. List Pager is written in Applesoft BASIC, is set up for a Centronics 730 printer, and requires one floppy-disk drive.

To use List Pager, the program to be listed must first be captured as a text file. This can be done using a program such as Capture, which is found on page 76 of the *Apple DOS* manual. When List Pager is run, it will ask for the title of the program, the name of the text file, and if an offset (60-column format) for hole punching is desired. After this information is entered, it will print the listing.

This program greatly improves the readability of a listing over that of continuously printed listings, which always seem to have an important line written on the perforations between pages. ■

Listing 1: *The List Pager program printed in a 60-column format with 10-column margins. The List Pager can also list programs in full 80-column format. List Pager places a title on the first page of a listing and numbers on subsequent pages. The program is written in Applesoft floating-point BASIC for the Apple II or II Plus computer with one disk drive and a Centronics 730 printer.*

```
100 D$ =  CHR$ (4):T$ =  CHR$ (1): ONERR  GOTO 390
110 RO = 0:LM = 1
120  HOME : HTAB (15): PRINT "LIST PAGER": PRINT : PRINT
130  INPUT "TITLE IS ? ";TITLE$: PRINT : PRINT
140 PG = 2
150  INPUT "TEXT FILE IS ? ";TF$: PRINT
160 LW = 80
170  PRINT "OFFSET FOR HOLE PUNCH ? (Y/N) ";: GET AN$: PRINT
 T$;AN$
180  IF AN$ = "Y" THEN LW = 60:LM = 10
190  HOME : PRINT D$;"PR#1"
200  PRINT  CHR$ (9);"80N"
210 DS = ((80 -  LEN (TITLE$)) / 2): HTAB (DS): PRINT TITLE$
: PRINT  CHR$ (10): PRINT  CHR$ (10)
220  PRINT D$;"OPEN ";TF$
230  PRINT D$;"READ ";TF$
240 PL = 4
250  PRINT  CHR$ (9);"80N"
260 LN$ = "":L1$ = ""
270  GET A$: IF  LEN (LN$)   240 THEN LN$ = LN$ + A$: GOTO 2
80
275  IF  LEN (LN$)   240 THEN L1$ = L1$ + A$
280  IF LN$ =  CHR$ (13) THEN  GOTO 260
290  IF A$ =  CHR$ (13) THEN  GOTO 310
300  GOTO 270
310  PRINT T$;:LE = 1
320 LH =  LEN (LN$) +  LEN (L1$):LE = 1: FOR I = 1 TO 10: IF
 LH   (LW * I) THEN LE = I + 1: NEXT I
330  FOR I = 1 TO LE: IF I * LW   241 THEN L$(I) =  MID$ (LN
$,((I - 1) * LW + 1),LW)
335  IF I * LW   240 THEN L$(I) =  MID$ (L1$,(((I - 1) * LW
+ 1) - 240),LW)
339  NEXT I
340 PL = PL + LE
350  IF PL   60 THEN PL = PL - LE: FOR I = 1 TO 66 - PL: PRI
NT  CHR$ (10): NEXT :RO = 1: GOTO 380
360  FOR I = 1 TO LE: HTAB (LM): PRINT L$(I): NEXT
370  GOTO 250
380  PRINT  CHR$ (10): PRINT  TAB( 60);"PAGE ";PG:PG = PG +
1: PRINT  CHR$ (10): PRINT  CHR$ (10):PL = 4: IF RO   1 THEN
 LE = LE: FOR I = 1 TO LE: HTAB (LM): PRINT L$(I): NEXT :PL
= PL + LE: GOTO 250
390  PRINT T$
400  PRINT D$;"CLOSE"
410  FOR I = 1 TO 67 - PL: PRINT  CHR$ (10): NEXT
420  PRINT D$;"PR#0": HOME : END
```

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Software Protection in the United Kingdom

Martin Hayman
Science Writers
80 Paxton Rd
London W4 2QX England

The first conference on software protection in the United Kingdom started with a joke and ended with a joke. In between, there was little to laugh about. In opening the conference, Alistair Kelman, a leading software copyright lawyer, told an old music-hall joke about an Englishman who asked an Irishman how to get to County Derry. The Irishman replied, "If I wanted to get to County Derry, I wouldn't start from here." In other words, Kelman suggested, if we had a choice in the matter of software protection, we would not set out from the point at which we find ourselves: ensnared by a tangled and thorny copyright law whose concepts spring from the days when the computer was little more than a fancy abacus in the mind of Charles Babbage.

The conference's closing joke came from retired software dealer and industry pundit Julian Allason, who proposed a "final solution" to the piracy problem: give the pirates free rein! Allason told how the American software house OEM is offering a "nonexclusive" licensing deal. For $460, OEM sells a complete line of programs, which the purchaser can dispose of as he wishes—for his own use, for copying, or for modification and resale. According to Allason, OEM intends its programs as "blueprints" that the purchaser can modify to meet his needs. But even so, an unnamed mail-order firm has already pirated OEM's products, offering the complete OEM line for a mere $260.

Held in March at the Waldorf Hotel in London, the Computer Software Protection Conference was subtitled "How to Beat the Pirates." The conference offered many suggestions on how to deal with the worldwide problem now reaching epidemic proportions in the UK. But the general conclusion was that the pirates can be beaten only by spending lots of time and money and retaining a knowledgeable lawyer from the outset.

The Backup Problem

Software theft has only recently become a problem in the UK. Hardware releases usually reach the UK about a year after introduction in the United States. In the one-year interval, Americans do a great deal of software development for the new machine. Because a question always exists about how and by whom the American software will be brought to the UK, the situation seems to offer great possibilities for software thieves.

Perhaps we should be surprised that VisiCalc, the world's best-selling program, was not copied here until late in 1980. VisiCalc retails in the UK at £125 ($290) and is distributed by Applied Computer Techniques (ACT) of Birmingham, the same firm that sells the Commodore PET, Britain's best-selling microcomputer. In December 1980, ACT discovered that a mail-order firm run by David Bolton was marketing what it called a "backup disk" for VisiCalc. The "backup disk" didn't contain a copy of VisiCalc but was preformatted in a way that enabled the user to defeat VisiCalc's protection routines and make a backup copy of the original disk from ACT. Bolton's backup disks sold like hotcakes, partly because ACT itself still will not give a registered user of VisiCalc a backup copy.

ACT promptly retained Alistair Kelman to apply to the High Court for an injunction to stop Bolton from selling the "backup disk," which ACT claimed was effectively a copy or an invitation to copy, and hence a breach of copyright relating to "artistic or literary works." After requiring ACT to get US suppliers Personal Software and Software Arts as

co-applicants in the injunction, the court found no reason to stop Bolton from selling his "backup disk."

Instead, the court simply passed a motion requiring Bolton to record all sales of the disk until some future day when the matter would come to trial. In the event of a trial, the motion would become the basis of any legal award for compensation. But even if Bolton paid up, the cost of recovery would far outweigh the damages themselves. The legal process is extremely slow in the UK, and the backup disk is still being sold. Furthermore, practice at the UK Bar forbids a lawyer from taking a case on a speculative basis. Counsel's fee for pleading is payable whether or not damages are recoverd. This makes "test cases" such as this one a rather Quixotic exercise.

Oblique Threat

In the Bolton case, an apparent attempt to persuade Bolton to desist may have undermined the position of the plaintiffs. On the morning of his appearance in court, Bolton received by mail a trade-newspaper clipping describing the somewhat similar case of Vincent Cohen. London police arrested Cohen in connection with the alleged theft and dishonest handling of source code belonging to the American firm Graham-Dorian Software. Detectives interviewed Cohen and were thought to be considering a charge of conspiracy. (By a quirk of English law, one need not actually conspire to do anything illegal in order to be charged with conspiracy.)

The Cohen case has now been settled out of court, but the case was very much alive when someone sent Bolton the clipping with the word "arrested" underlined. Clearly the sender of the clipping knew the date of Bolton's hearing, and that suggests the sender was an interested party. As Alistair Kelman pointed out, if a judge learned that a plaintiff had indulged in this sort of oblique threat, the plaintiff's case could only suffer.

Cohen, incidentally, appeared at the piracy conference looking unabashed.

To Be a Pirate

Against this background, Julian Allason's opening remarks are understandable. "If I were to start again in the software business," he said, "I would be a pirate. It's the quickest way to make money with the least risk that there is in Britain today. I would buy a wide range of programs, copy them and resell them by mail-order. Then if things went well, which they would, I would get bold and make the programs available to dealers. If the programs were so well known as to be obviously recognized, then I would describe them as 'backup copies.' "

Although Allason said additional precautions would probably be unnecessary, the aspiring pirate could put aside any fears by following American practice: change a few program lines, renumber the program, remove the serial numbers, advertise under a bland trade name, or buy a "cut-out" license from a company that has either gone out of business or bought its license from another dubious and short-lived company. The result is a "deck of cards" in which each company must be sued in turn. This wrinkle is a recent migrant to the UK, first making its appearance in the case of a backwoods outfit called Kansas City Systems.

Level IV, Anyone?

Despite its name, Kansas City Systems is literally a backwoods operation. Its premises are a shack in a forest near Chesterfield, in the north of England. One of the British distributors of Level III BASIC and an associated monitor, the Eastbourne software house A J Harding (Molimerx), took Kansas City Systems to court for pirating Level III and reselling it as Level IV. Kansas City Systems' chief, Tom Crossley, argued that he had bought the software from one Sorrell B Chapman, whom he met at a microcomputer show in Britain in 1979. According to Crossley, Chapman claimed to be legitimately selling the software on behalf of the now defunct GRT Corporation.

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English court to test the validity of the American "cut-out" license, but in this instance the plaintiffs won a qualified victory. Using an unusual legal instrument called the Anton Pillar order, the plaintiffs got hold of disks, documentation, and correspondence belonging to Kansas City Systems. The Anton Pillar order empowers the plaintiff's legal representative to act as an officer of the court in cases of suspected copyright infringement. The plaintiff's lawyer can require the defendant, without notice, to open his premises to a search and to let the plaintiff's representative take away any relevant documents. If the defendant refuses, he is in contempt of court.

The Knock at Night

Will the Anton Pillar order play an important role in the control of software piracy in the UK? Will pirates fear the knock in the middle of the night? Alistair Kelman calls the Anton Pillar order a "judicial invention," noting that Parliament has never debated this unusual provision for search and seizure. But the Anton Pillar order has already been used several hundred times.

Although most commonly applied in piracy cases involving phonograph records and music tapes, the order was first invoked in a case of computer piracy. Its namesake, Anton Pillar, was a German manufacturer of an emulator utility for IBM equipment. British distributors of the utility, however, started making unlicensed copies and selling them at cut rates. When Pillar found out, he sought an injunction to stop the pirates, and he successfully argued that the evidence needed to prove infringement could only be seized by a search that took the offenders by surprise.

Kelman noted that at the top end of the market, much business can be lost through organized software piracy. "There is now a risk from organized crime—the big sharks who will be a real menace as the market develops," he warned. But so far, little evidence of organized crime involvement has surfaced. In typical piracy cases,

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dealers supply a "complimentary" copy of one disk instead of a discount on another; or a service engineer "just happens to have" a word-processor program that he can get the customer for a cash discount—say of 90 percent.

Only Amateurs

Home copiers, as distinguished from professional bootleggers, drew sharp words from Allason. Claiming that amateurs account for 99 percent of illicitly copied programs, Allason revealed the results of a confidential survey of PET users in the UK. For every program bought from a legitimate source, Allason found, two and a half copies were made without permission. The UK trade paper *Computer Weekly* confirms Allason's figures. Commodore says its software cassette market has slumped to only 40 percent of what it was a year ago. Even with many PET users changing to disk, such a decline in cassette sales puts an intolerable strain on the market.

Is copying in the home less pernicious than professional bootlegging? From the amateur's point of view, illicit copying might seem a good thing. Certainly the surroundings are innocent enough; this sort of copying takes place mainly among friends, at schools, and in user groups.

But amateurs confront software publishers with a dilemma: if publishers take no steps to protect their programs, making a copy becomes the easiest thing in the world. On the other hand, if publishers use protection routines, making a copy is for many amateurs the most enjoyable thing in the world. Unlike semiprofessional users of software, amateurs have both the time and the enthusiasm needed to defeat protective measures. Peter Laurie, editor of *Practical Computing*, confirmed Allason's view by saying, "Any intelligent teenager will make it (overcoming copy-protection measures) his first task of the day."

The case of Microchess shows how severely amateur copying can damage software sales. Before the International PET Users' Group published a method of copying Microchess, the game program had sold more than 100,000 copies. After publication of the copy method, sales dried up. By contrast, the semiprofessional program Wordcraft enjoyed a dramatic increase in sales when the protection routine known as the "Dongle" was incorporated.

The Price of Free Copies

The amateur's own long-term interests are actually damaged by copying software at home, according to Allason. As royalties decline, both authors and publishers become reluctant to publish. Until recently, ACT published 200 titles; its list has now dwindled to 20. The company no longer finds it worthwhile to publish, document, and support a long list of marginal sellers. Instead, ACT leaves programs with a small market to smaller firms that skimp on documentation and support, or to bootleggers who provide no support and who would never consider providing documentation. Because documentation is clearly a written work, it is subject to the provisions of the Copyright Act.

Allason named some programs whose publication stands in jeopardy because of pervasive software piracy. Among them are a financial modeling program called Nebula, produced at a cost of $600,000; Micromodeler, which was to have sold for $900; and Dr Michael Brinson's elegant and useful AC Circuit Analysis, withdrawn from the marketplace.

In brief, Allason said amateur piracy will have five consequences for the average software buyer. It will reduce the range of software available, raise prices, and make companies reluctant to invest in software development. He said piracy also leads to lack of support and maintenance, and discourages development of software by cottage industries which cannot afford to go to court to protect their interests.

Allason disagreed with those who claim the solution to piracy is to reduce prices paid by consumers. He cited a survey showing that programs

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are copied whether they're priced at $7 or $400.

Few Are Innocent

Consultant Ian Litterick approached software piracy with an honesty that refreshed some and horrified others. Stepping up to speak on "Why I Am a Software Thief," Litterick asked, "Which of you can say, hand on heart, that you have never made a copy, or used one knowingly?" Fewer than five people raised their hands.

Buoyed by this mass confession, Litterick assuaged everyone's guilt by arguing that bootleg copies are indispensable for software evaluation. In the hectic and hyped atmosphere of a store, he said, real evaluation is impossible. Authors of good software have nothing to fear from unauthorized copies, according to Litterick. "If it's a good package," he claimed, "then there are compelling reasons why I should go on to buy it in the conventional way."

Litterick's speech implied that the unseen "customer" actually plays a vital role in the development of software. With the help of the amateur pirate, poor programs are gradually winnowed out, leaving the kernel—the 100-percent debugged, easy-to-run, and magnificently documented software—selling for a song. If only authors and publishers would show a little more gratitude!

A great many amateurs would probably endorse Litterick's second point: a single-disk user *must* have a backup copy, especially if he has both data and program on the one disk. What's more, Litterick said defiantly, what can any of the manufacturers do if the determined thief goes for bit-by-bit copying?

Countermeasures

The conference raised many ideas for fighting software piracy. Some are new and theoretical, but most are already familiar to Americans. Allason ran down a list of anti-pirate weapons that he thinks should be brandished immediately:

- "Megabuck" lawsuits—the cost-attrition weapon.



• The embarrassment factor. Perhaps saying "You know that I know" will be more effective in the UK's smaller, more centralized economy than in the US.
• Induced dependence, a strategy used by mainframe manufacturers who claim that only they can give customers the documentation and backup they need.
• Licensing of users, generally considered the most effective weapon against piracy.

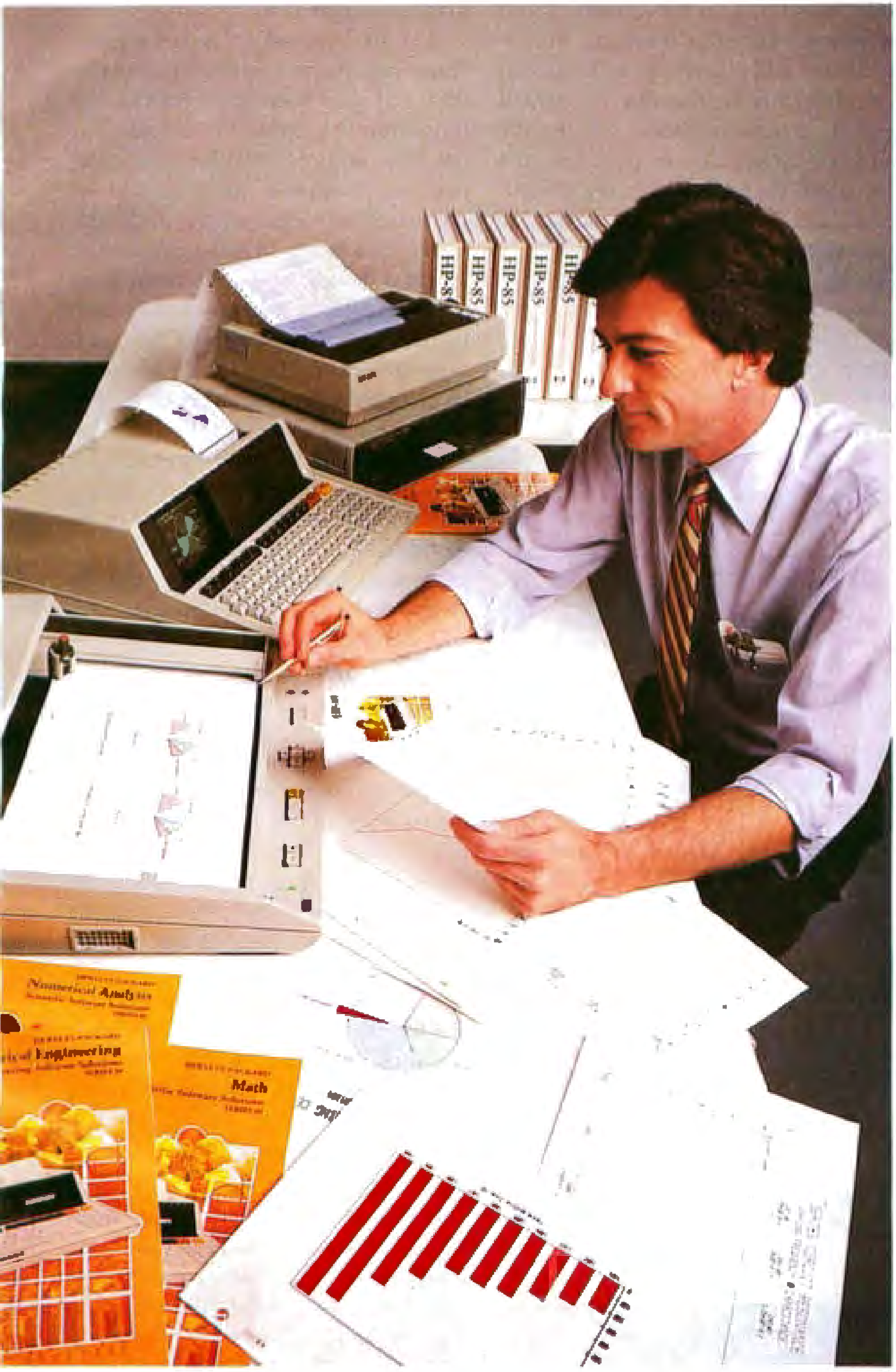
Laurie believes licensing is the *only* effective way to combat pirates. Although amateurs are too numerous and energetic to be stopped from making illicit copies, vendors can stop real pirates by using existing provisions of law to secure agreements at the point of sale. If the supplier's name is visibly coded in at the beginning of a program, and invisibly coded in elsewhere, there is a legal basis for enforcing the original license agreement. The visible trademark establishes a breach of contract; the invisible, if the illicit copier expunges it, establishes a breach of copyright.

When programs are intended for the mass-market microcomputer, Laurie sees a contradiction in trying to discourage copying by making the programs hard to use. Software is made to be used; in fact, a license should permit the licensed user to make the modifications he needs. Tying software to a specific machine or implementing a turnkey system would be self-defeating.

The Case of ChessBall

Alistair Kelman gave the conference a detailed and analytic look at the state of the legal theory of software protection. In both British and American law, the most desirable form of protection for a computer program is a patent, which confers a monopoly on the owner. Unfortunately, in the UK the Patent Act of 1977 specifically excludes computer

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software. But Kelman showed how, in the realm of computers, the artificial distinction between copyright and patent can make a monkey of the law.

Kelman described a game called ChessBall, invented by patent agent Paul Cole. A board game combining chess and football, ChessBall is played by two teams of three players—a Knight, a Queen, and a Bishop. The ball is on a grid and reacts to the arrival of a player in one of the surrounding squares according to a complex set of rules. Goalposts stand where the King and Queen are situated on a normal chessboard. The object of the game is to score as many goals as possible in a set period.

"It is possible to sell ChessBall as a board game, and it might be possible to obtain a patent for it," Kelman said. "However, it is also possible to sell ChessBall as a tape which could be loaded into the domestic microcomputer and played by the family. It would further be possible to make a special microcomputer where the game of ChessBall was built into the electronic circuits. Under the present law, the game on tape is not patentable but the designated micro might well be."

These ideas were elaborated upon by Laurie, who advanced the idea that a "device" is patentable and hence enjoys the protection of patent law, which is far more bulletproof than copyright law.

"Let us suppose," Laurie argued, "that you have a bright, patentable idea and wire together some discrete transistors to make it work. The result is certainly a device and can be patented. Suppose that you take an uncommitted logic array and configure it to work like the transistors. Again a device, and patentable. Suppose you use a microprocessor controlled by a program in ROM (read-only memory). The ROM is physically changed by programming it. The same program in EPROM (erasable programmable read-only memory) is also a device, even though the alteration to the basic structure is just in the distribution of charge." If the program is in dynamic memory and the charge lasts only a millisecond, it's still a device, he said.

By a quirk of the British Patent Law of 1977, a person can commit "contributory infringement" of a patent if he helps someone else infringe the patent by, for example, providing instructions about how to do it. By this means, Laurie argued, it is theoretically possible to catch the software pirate. The pirate may, he said, be giving "instructions" in the form of software which, once loaded, becomes a patent infringement under the terms of the Act. This approach may or may not work; certainly nobody in the UK has had the nerve to put it to the test.

New Concepts

In the process of trying to overhaul the Copyright Act of 1956, Kelman has suggested some new concepts that may help clarify legal thinking about the intellectual property called software. One important concept is that of "transitory reproduction."

According to Kelman, a transitory reproduction occurs when, for example, a program is read into memory

and used to perform a particular task. Although the program itself may be a copyright work, no blame is attached to using and reproducing the program for the brief period of its appearance on the video display terminal. Nor does the use of the copyright work dilute in any way the copyright of any material which the transitorily reproduced program has processed.

Kelman has proposed a new concept called "transmutation" to describe any computing whose final effect is to steal one person's program and render it in another form. He defines the term as the automatic conversion of a source work into an object code by electronic, mechanical, or similar techniques. Transmutation is intended to cover such familiar words as "compile," "assemble," and "interpret," which already have specific meanings in law and computer science.

British courts already have groped with the concept of transmutation, but the current copyright law has shown itself unable to cope with the new concept. A notable instance is a recent case in which Sinclair Electronics sought an injunction against Compshop, which Sinclair alleged had copied the design of Sinclair's ZX80 pocket computer kit and introduced the copy in the US. Kelman bemoaned Justice Megarry's position that information held in ROM could not be copyright "because he couldn't see it." Kelman asked whether the rights to the Justice's own work, *Manual of Real Property*, would disintegrate if the manual were entered into the memory of a computer as a code, and then accessed by someone asking questions in "computer language."

International Complications

Although Kelman's concept of transmutation has found some favor with European lawmakers trying to draft a harmonized copyright law for Europe in the 1980s, important differences exist between Continental and Anglo-Saxon laws on intellectual property. These differences may complicate international software protection. The Continental concept of "moral right" to intellectual property is an example. In the US and the UK, an author sells intellectual property in much the same way as he would sell a piece of furniture. The author gets money in exchange for rights to the property. According to Continental tradition, however, the author retains the right to have his name associated with his work, and to stop unauthorized versions of his work from appearing, *whether or not* he has sold, given away, or otherwise disposed of his *pecuniary* rights with respect to the work.

Will Continental programmers be able to wield the concept of "moral right" in defense of their creations? If so, could the Anglo-Saxon world borrow the concept? Will North American and British programmers be able to defend their rights by pressing the important distinction between "transitory reproduction" and "transmutation"? Until these questions are answered, software authors and publishers can only hope to enforce license agreements signed at the point of sale. The laws on software piracy are all buckle and no swash. ■

Network Tools
Ideas for Intelligent Network Software

Peter B Reintjes
Rte 3 Box 85
Morehead City NC 28557

Some people foresee electronic information as the currency of the future: those who have it will use it to get more, and those who don't have it will be exploited. Actually, money probably will continue to be the currency for years to come, but the computer will be the primary tool for controlling its flow. The key to this flow lies in computer networks. With the price of individual computers dropping, more people are solving their problems with computer networks, rather than with a single large computer.

Networks are more than just connections between computers. The physical connection—be it a twisted-wire pair, phone line, or satellite transmission—is of little consequence compared with the software that *uses* the connection.

Personal Computer Networks

Most network software developments aim to define protocols with sufficient generality to last a decade or more. ARPAnet, X25, and Ethernet, all primarily computer-to-computer networks, are now the focus of computer vendors' attention.

But another group of networks uses computer-human interfaces to provide interactive services. News and mail systems, shopping marts for software releases, and bulletin boards all fall into this category.

In these networks, information clearly is not currency but instead the *commodity* being paid for. (You may become painfully aware of this upon receiving monthly bills from the telephone company and the "information utilities.")

As a personal computerist, you have special needs that should be taken into consideration by the networking software. Ideally, your home computer should become an intelligent node on the network, making the network connection process invisible to you. Under such a system, your computer can call up the information service at night, when rates are lowest and the network response time is probably at its best.

An intelligent node system has another valuable application: a set of files on one computer can be transferred automatically to another node on the system. Each night when the network is activated, system A calls system B to determine which one has the latest version of each file. The updated file is then copied over the outdated one. You can spend all day Friday editing your resume on system A at work or school, then get up Saturday morning to find the edited version in your home computer's file, ready for further use or revision. A similar procedure could be used to send revisions of operating systems and even the network programs themselves. The command to activate the network can be executed at any time if a transaction is required before the usual late-night activation.

An Intelligent Node Program

With the needs of the personal computerist in mind, I have designed a set of modules that provide a basis for networking. I tried to make the modules very general, as well as compact and efficient enough for use in an actual networking system. In any event, the modules should prove useful in trying out new protocols and adapting quickly to different network interfaces.

Designing a network from the ground up provides the advantages of control over the planning and regulation of protocols and transactions. James Martin's book *Systems Analysis for Telecommunications* is recommended to anyone interested in designing a network. Another valuable book is *Software Tools* by Kernighan and Plaugher, from whom I have borrowed the idea of presenting modular programs as a set of tools. In this case the tools are for developing a network system.

Desirable as it may be in some ways, designing your own network creates the immediate problem of interfacing with all other information services. For the microcomputer owner, a more realistic goal would be designing a general-purpose interface to converse with other machines on the network, and then designing a local protocol to "ride on top" of the interface. The designers of the X25 network architecture anticipated this problem when they specified X25 in several distinct layers. Only the lowest level is in contact with the network. The higher levels behave as if they were sending and receiving data

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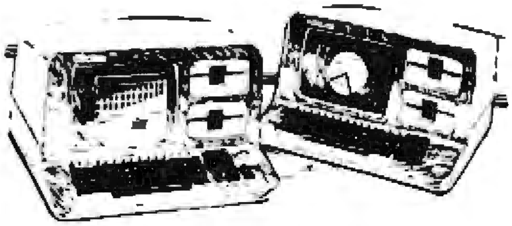
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across the network in a more abstract way.

The lowest (physical) level of any network can be implemented with my proposed networking modules. The user level could be fashioned to appear the same as X25 or the ARPAnet.

The following specifications describe software modules needed for a basic network capability. The source codes for five of the functions—DIALER, PROMPT, CONVERSE, TRANSLUCID, and TRANSACT—are given after the specifications. These functions can be implemented in whatever language is available, and under any operating system or monitor the user chooses. Once the functions are available, the environment will be reasonably independent of the operating system, and future utilities designed for this environment will be easier to install. The functions can make the network protocol easier to implement and put the transaction processing on a high level.

WATCHDOG and ALARM

Networking, a real-time process, is slow and has a wide tolerance for speed fluctuations. But because protocols still must be executed in the proper sequence and in a consistent time frame, interrupt handling is needed for timing functions as well as for input and output.

Many large networking computers have multiprocessing operating systems. They can have several tasks running at once, trading off central processing unit (CPU) cycles, and each task can be doing part of the job. The most important tasks are the ALARM and WATCHDOG functions, and I have included them among the modules. ALARM tells the system when it is time for a transaction, or when certain services are available on the network. WATCHDOG watches the network traffic and steps in if a conversation gets bogged down in protocol.

In networking, perhaps more than anywhere else, error recovery is crucial. When two computers are talking over a voice-grade line at 4:00 in the morning, they could easily get out of step on a bad byte. In this case, you would at least want to make sure a telephone connection is broken, and you probably would like the computers to settle their differences without waking someone up or having to start from scratch the next night. This level of error recovery may sound formidable, but a few strategies can solve most common problems while enabling your computer to decide when it is hopeless to continue trying.

The WATCHDOG and ALARM functions can also be implemented on the typical personal computer system without multiprocessing. A timer with interrupt capability is required, and a real-time clock with interrupt alarms would be best.

Both the WATCHDOG and ALARM functions can be implemented in the same timer-interrupt routine with a global flag to signify whether the normal ALARM mode or the WATCHDOG mode is active. In using the ALARM function, a pointer in the AGENDA (a file specifying the transactions that need to be performed) shows what the next activity is and when it is scheduled. The timer is then set for activation, and the process goes into a wait state. When the interrupt occurs, the interrupt handler notes that it is in the alarm mode and jumps to a routine which starts up the desired activity.

If you are starting a process which may get hung (meaning you may wait forever for a transaction to be completed), set the TIMER function to WATCHDOG, start the timer and start the process. If the process is not finished before the timer causes an interrupt, the handler will see that it was activated as a WATCHDOG, and it will look around for an incomplete transaction. Then it can clean up the failed action, closing or removing any files the transaction used and incrementing a counter to keep track of the number of failures. If this counter exceeds a certain threshold, the transaction will be removed from the agenda and

JUST LAUNCHED!
VOYAGE OF THE VALKYRIE
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*Trademark of Tandy Corp.

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reported as a failure.

The flow of control when the timer interrupt occurs is shown in figure 1. The timer-interrupt handler provides the synchronization. When the system has finished its nightly transactions, it may print a status report similar to the one in figure 2.

TIMER

Set the timer to wait for a specified time. It can be set in seconds, minutes, or until an actual hour if a real-time clock is available. When the time is up, the interrupt routine will be activated, either in the WATCHDOG or ALARM mode.

DIALER

DIALER is a procedure for dialing the phone number of the remote computer. This software (see listing 1), plus a simple relay driven from an output port, can substitute for an expensive auto-dialer. Because telephone service supports pulse dialing even in areas with Touch Tone service, this procedure is a very cost-effective way for your computer to make phone calls. The phone number is represented as an array of 20 characters. The only valid characters are the digits 0 through 9 and a dash (—). The dash is interpreted as a pause in the dialing sequence.

PROMPT

This routine, shown in listing 2, is called with a sample prompt string and a pointer to a buffer of text. It determines whether the prompt occurs in the text, returns the offset into the buffer, or returns a negative number if the prompt is not found.

When you are conversing with a remote host system, a prompt from the host signals that the system is waiting for a command. On IBM's OS-360, it might be the word READY and a new line; on the UNIX operating system it is usually a percent sign followed by a space. Your system needs to recognize the prompt coming from the remote system and respond to it appropriately. This recognition is especially useful during the log-on procedure, when the system may have a status message of indeterminate length.

An alternate scheme for recognizing a prompt in the input stream is detailed in the TRANSACT procedure.

CONVERSE

The CONVERSE function in listing 3 attempts to carry on the dialog con-

Text continued on page 154

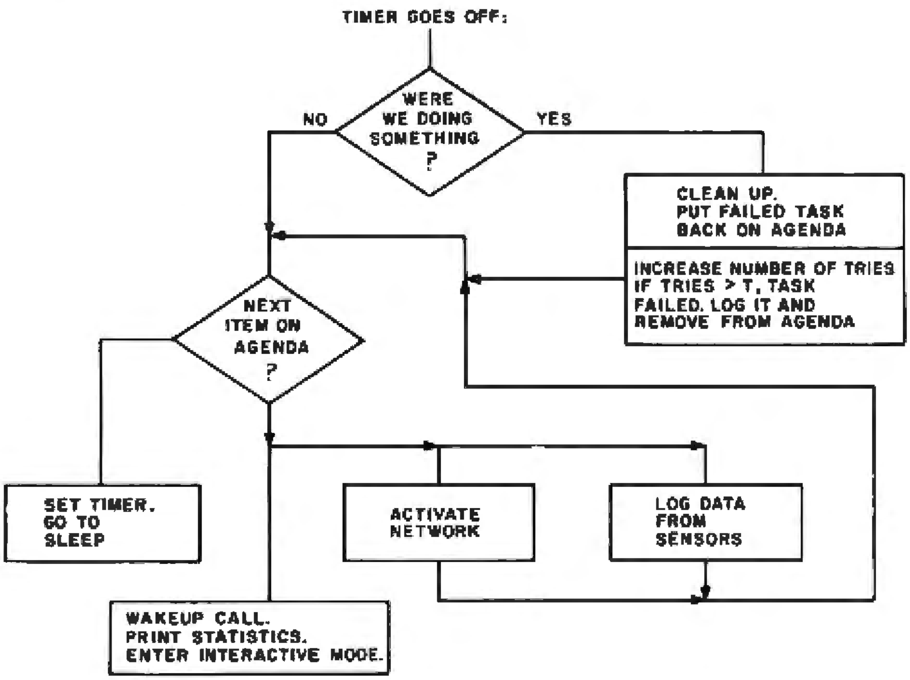


Figure 1: *Flow of control when the timer goes off.*

```
                Good Morning

        Nocturnal Network Summary  8:02  May 19, 1981

Successful Transactions  Time on  Time off    #      tries

     MAIL; NEWS            2:03     2:18   666-6666    1
   FILE x from remote      2:19     2:40   777-7777    2
   FILE y to remote
     MAIL; NEWS
     NEWS                  3:10     3:20   888-8888    1

Unsuccessful Transactions

   FILE n to remote        3:45     3:50   111-1111    4
     MAIL                  3:55     4:10   222-2222    4
```

Figure 2: *A sample report summarizing the activities of the preceding night.*

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*CP/M is a trademark of Digital Research Corp.

Listing 1: *The module for dialing a telephone number using a simple relay to create pulses.*

```
module dialer;
     (*****************************************************************)
     (*                                                               *)
     (*  Dialer is a function which alternately opens and closes      *)
     (* a relay on a phone's hook switch to 'dial' the number of      *)
     (* the remote computer.                                          *)
     (*                                                               *)
     (*              Copyright  1981  by Peter Reintjes              *)
     (*                                                               *)
     (*****************************************************************)

type
        phone_number = ARRAY [1..20] OF CHAR;


const
        HMASK =    100; (* bit in register for relay   *)
        PAUSE =  10000; (* constant for pause          *)
        HI_DC =    400; (*  These two numbers set the  *)
        LO_DC =    600; (*   duty-cycle of the relay   *)

var
      i, j, n: INTEGER;
      c      : CHAR;
      exit   : BOOLEAN;

external assembly procedure relay( data : INTEGER);



procedure high;
        var
                i : integer;
        begin
       (* relay is an assembly language routine to set the *)
       (* output port for the dialer to  the  value  HMASK *)
          relay(HMASK);           (* turn bit on *)
          for i:=0 to HI_DC do ;  (* relay on  *)
        end;



procedure low;
        var
                i : integer;
        begin
          relay(-HMASK-1); (* this inverts HMASK *)
          for i:=0 to LO_DC do ;  (* relay off *)
        end;

entry procedure dialer (telenum: phone_number);
     (* telenum is at most 20 chars, terminated with a null *)

begin           (* begin dialer *)
      (*  null char is after the last digit in the array *)

             for i:=1 to 20 do begin
                c := telenum[i];
                case  c of
```

Listing 1 continued on page 150

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Listing 1 continued:

```
                 '<0>': exit := true; (* null character *)

    '1','2','3','4','5',
    '6','7','8','9','0': begin
(* integer value of digit *) n := ord(c) - 48;
                             if (n=0) then n:=10;
                             for j:=0 to n do begin
                                              high;
                              (* toggle relay *) low;
                                             end;
                         end;

                  '-': for j:=1 to PAUSE do; (*pause*)

              otherwise  begin
                           writeln('error: bad digit ',c);
                           exit := true;
                         end;
                    end;   (* end of case *)
                if (exit) then exitloop;
            end;
    end;
```

Listing 2: *The module to recognize a prompt from the host computer and take appropriate action.*

```
module prompt;

 (*****************************************************************)
 (*  Prompt is a function which searches a text buffer for an    *)
 (* occurrence of the 'prompt' a string specified in the array   *)
 (* pmt[]. It is called prompt because it will most often be     *)
 (* used to wade through extraneous system chatter to determine *)
 (* if the remote system came back with a 'prompt'.             *)
 (*                                                              *)
 (*             Copyright  1981  by Peter Reintjes              *)
 (*                                                              *)
 (*****************************************************************)
type
        buffer  =  ARRAY [0..2047] OF CHAR;
        buf     =  @buffer;
        prom    =  STRING 50;

entry function prompt(pmt: prom; bptr: buf; off,len:INTEGER):INTEGER;


var        c      : CHAR;    (* temporary character *)
        i,p     : INTEGER;
        lpmt    : INTEGER;
        found   : BOOLEAN;  (* boolean true when prompt is matched *)

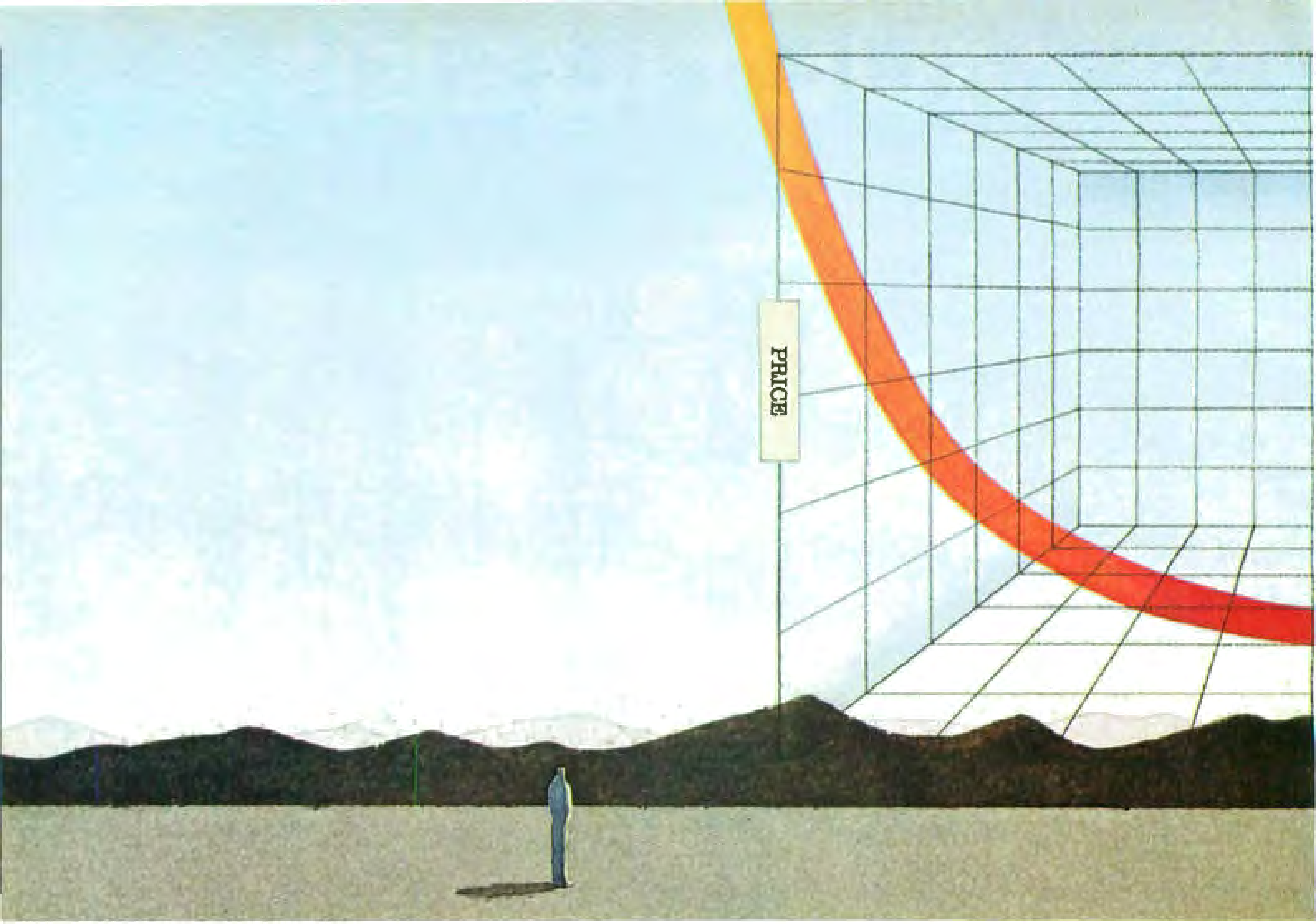
 begin

            found := false;
            lpmt := length(pmt);
            p := 0;               (* pointer in  text  buffer *)
            c := bptr@[p+off];  (* c gets  first  character *)

        while( NOT(found) AND (p<len-lpmt) ) do begin
```

Listing 2 continued on page 154


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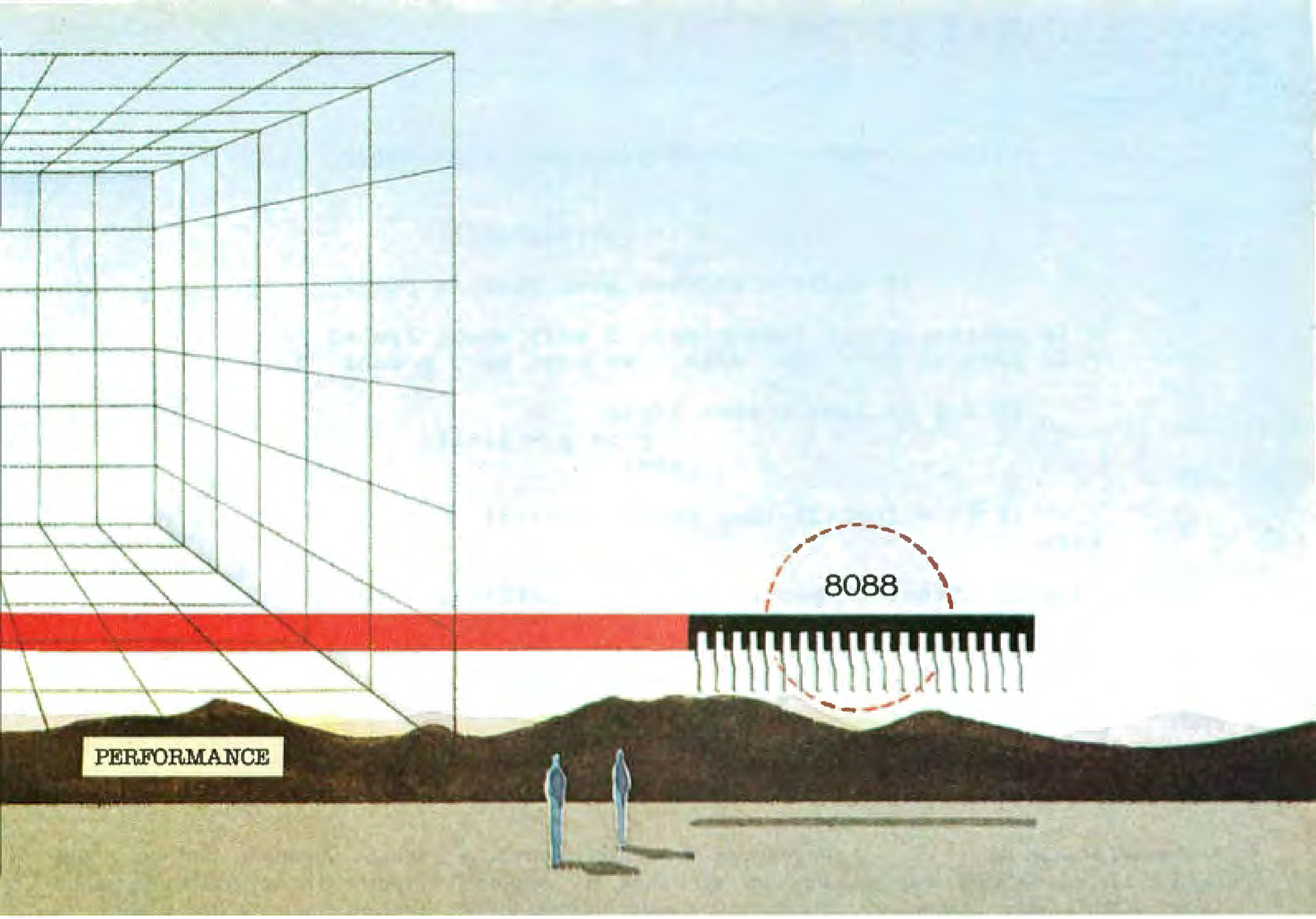
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Computer Graphics	*1.0*	*0.1*	*0.05*
16-bit Multiply	*1.0*	*0.17*	*0.5*
Block Move	*1.0*	*0.75*	*0.49*

Full details of these benchmarks available in the iAPX 88 Book.


8088
PERFORMANCE

Listing 2 continued:

```
            i := 1;
            while( (c=pmt<<i>>) AND (i<=lpmt) ) do begin
                                    i := i + 1;
                                    p := p + 1;
                                    c := bptr@[p+off];
                                    end;
                       (* while c matches next char in pmt*)

       (* if entire prompt recognized, i will equal lpmt+1 *)
       (* if part of pmt  was  seen,  we must move p back  *)

            if ( i <= lpmt ) then begin
                                       p := p - (i-1);
                                     end;

            if (i = lpmt+1) then found := true;
       end;

   (*  if found, offset of prompt into text buffer passed *)

        if found then prompt :=  p
                 else prompt := -1;

end;
```

Text continued from page 144:
tained in the file SCRIPT. For instance, SCRIPT may contain the dialog necessary to log on to the remote system. This function will be invoked after the number has been dialed and the remote system has answered. If CONVERSE does not get the response it expects at any point in the conversation, it can drop back to an earlier part of the conversation and try to pick up the thread. However, if it continues to find errors and can't get through, it will give up and tell the transaction processor to try again later.

CONVERSE allows the system to log on to interactive services designed for a human interface, and to give the local system access to these services without operator intervention. It also lets you test new protocols by providing a table-driven protocol handler.

If the remote system has a response used to indicate an incorrect sequence (for example, INCORRECT USER NAME—TRY AGAIN), that response should be included in the model of a normal dialog. Giving the remote system an empty line instead of your user name might be one occasion for generating the response. Having this message in your dialog will give you a recovery point. If something happens later in the dialog and the system responds with INCORRECT USER NAME—TRY AGAIN, you will be able to pick up the conversation at the appropriate point.

CLEANUP

If the WATCHDOG wakes up and sees that a specified transaction was active, it calls the CLEANUP function to shut it down. If the number of tries for this transaction exceeds a predetermined limit, it is taken off the AGENDA.

TRANSLUCID

This is a shell, or command-line, program which interacts with the user at the keyboard. The primary function of TRANSLUCID, shown in listing 4, is to make the local computer look like a terminal, passing information from the user's keyboard to the network and sending the data from the network to the local video display or printer. A secondary, and equally important, function of this program is to redirect the information flowing through it into a file, or to use files as the source of text to be substituted for the keyboard. Using the "transparent" monitor to conduct transactions manually will show you the dialogs which must take place between the computers.

The GETC and PUTC functions handle character input and output from the user terminal or files designated by the redirection commands. GETREMOTE and PUTREMOTE serve the same function on the network (modem) side. The first parameter to these routines specifies the channel over which the data is received or sent. The channels in my examples are the terminal input (STDIN), the output channel to the terminal screen (STDOUT), the output to the modem (NETOUT) and the return data from the modem (NETIN). All other channels in the programs are to files on the local system.

The second parameter is the character variable, and the third (GET functions only) is the WAIT/

Text continued on page 163

Listing 3: *The input/output module, CONVERSE.*

```
module converse;

   (*******************************************************************)
   (*                                                                 *)
   (*  Converse is a function which alternately transmits lines of   *)
   (* text and receives them from the remote unit. It monitors this *)
   (* conversation as it proceeds,  attempting to recover if it     *)
   (* gets out of step. It then returns 0 if the conversation was   *)
   (* successful and a -1 if it failed.                             *)
   (*                                                                 *)
   (*                Copyright  1981  by Peter Reintjes              *)
   (*                                                                 *)
   (*******************************************************************)


external procedure putremote ( c : CHAR );
external function  getremote ( var c : CHAR; wflag : BOOLEAN ):INTEGER;
entry function converse(fname: STRING 20) :INTEGER;

      (* fname is a file of text strings terminated by NULL. *)
      (* Every other string  starting with the first one is  *)
      (* what the local unit sends, the next line is what we *)
      (* expect to get back. The file starts with a NULL and *)
      (* is terminated  by two or more NULLs.                *)


     const
        NULL =    '<0>';  (* reference  character       *)
        ATTN =    '<12>'; (* interrupt remote computer *)
        HOLD =     100;   (* max time delay for each    *)
                          (* character from the net     *)
        wait    =   true;
        nowait  =   false;  (* options for getremote call *)

     var
          c, cn       : CHAR;
          i           : INTEGER;
          errors      : INTEGER;
          error       : INTEGER;
          done        : BOOLEAN;
          giveup      : BOOLEAN;
procedure recover; (* call this as many times as you want *)

     var
          reply          : STRING 180; (* longest response from remote *)
          found          : BOOLEAN;
          error,i,time :  INTEGER;

   begin

      if ( c <> NULL ) then begin  (* error recovery *)
               errors := errors + 1;

               putremote(ATTN);  (* get remote's attention *)

               reply := '';   (* null string for response *)
               time := 0;     (* wait  for  the  response *)
               while ( time < HOLD ) do begin
                       error := getremote(c, nowait);
```

Listing 3 continued on page 156

Listing 3 continued:

```
                        if (error = 0) then begin  (* we got one *)
                                       append(reply,c);
                                       time := 0;
                                       end;
                        time := time + 1;
                end;

        (* If we waited long enough, the response is in reply *)
        (* if there's no reply then the remote system is dead *)
        if (length(reply)=0) then giveup := true;
        if (giveup) then exitloop;

        (* now we search the file for the system's response  *)

                reset(infile,fname);
                read(infile,c);
                found := false;
                while ( NOT found AND NOT EOF(infile)) do begin
                   read(infile,c);             (*  read  past  NULL  *)
                   if  EOF(infile) then exitloop; (* being cautious *)

                   (* read past local part of conversation *)
                   while ( c <> NULL ) do read(infile,c);
                   read(infile,c);              (*  read  past  NULL  *)
                   if  EOF(infile) then exitloop;

                   i := 1;
                   while((i <= length(reply))AND(c = reply<<i>>)) do begin
                        read(infile,c);
                        if  EOF(infile) then exitloop;
                        i := i + 1;
                   end;
                   if  EOF(infile) then exitloop;
                   if((i>length(reply))AND(c=NULL))then found := true;
                   while ( c <> NULL ) do read(infile,c);
                   if  EOF(infile) then exitloop;
                end;

      if ((c<>NULL) OR EOF(infile) OR (errors>10)) then giveup := true;
      end;
end;    (* end of error recovery *)

                (*   Main procedure CONVERSE    *)

begin
     errors := 0; (* keep track of error recovery attempts *)
     done := false;   (* we've only just begun *)

     reset(infile, fname); (* open script file *)

     read(infile,c);
     while ( NOT EOF(infile) AND NOT done ) do begin
                while( c <> NULL ) do begin
                        write(netout,c);
                        read(infile,c);
                end;

                read(infile,c);

                while (c <> NULL) do begin
                  read(infile,c);
```

Listing 3 continued on page 158

Listing 3 continued:

```
                    i := 0;
                    while ( i < HOLD ) do begin
                          error := getremote(cn, nowait);
                          if ( error = 0 ) then i := HOLD;
                          i := i + 1;
                    end;
                    if ( c <> cn ) then exitloop;
                  end;

        (* c should now be at  the  NULL  before  the  local  *)
        (* system's  next  statement.                          *)
        (* If c <> NULL at this point then there was an error *)

             (* try to pick up conversation *)
        while ((c <> NULL)AND(NOT giveup)) do recover;

        if (NOT giveup) then begin
           read(infile,c);
           if ( c = NULL ) then done := true;  (* two NULLs in a row *)
           end;

     end;    (* conversation complete *)

             if (done) then converse :=  0  (* worked *)
                       else converse := -1; (* failed *)
end;
```

Listing 4: The command processor "shell" program, TRANSLUCID.

```
program TRANSLUCID(input,output);

const    ENDOF      =    -1;
         NL         =    '<012>';
         ESC        =    '<176>';
         wait       =    true;
         nowait     =    false;

type
         cfile = FILE OF CHAR;
var
  network: TEXT;        (* Fake network data source              *)
  netout : TEXT;        (* Fake network data sink                *)
  auxfile: TEXT;        (* One file may be opened for aux output *)
                        (* Up to 9 files may  be  opened  for    *)
                        (* input.                                *)

  macfile: ARRAY [0..9] OF cfile;  (* array of file descriptors *)
  level  : INTEGER;
  done   : BOOLEAN;
  c      : CHAR;
  error  : INTEGER;   (* error flag back from get and put calls *)
  aux,app: BOOLEAN;   (* true if we have an auxillary file open *)
  fname  : STRING 20; (* Filename for rewrite or reset calls    *)

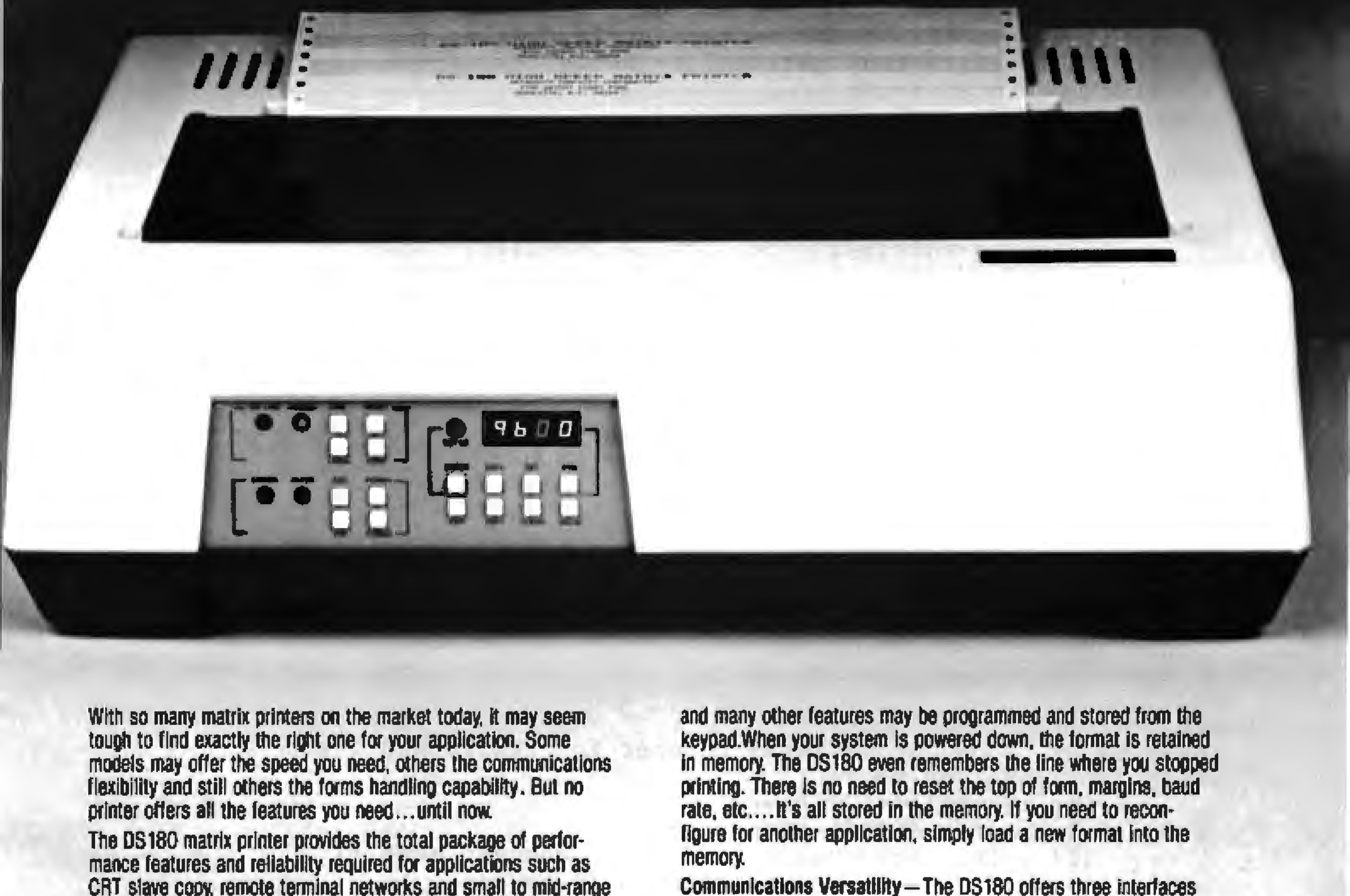
external function  getc(fdesc : FILE OF TEXT;
                        var c :CHAR;
                        wflag :BOOLEAN)  : INTEGER;

external procedure putc( fdesc: FILE OF TEXT; c :CHAR);
```

Listing 4 continued on page 160

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```
function  fgetc(var c :CHAR) :INTEGER;
        (* file-get keeps track of the multiple inputs *)
        (* like the include facility of most languages *)
    begin
        read(macfile[level],c);
        if(EOF(macfile[level])) then fgetc := ENDOF
        else fgetc := 0;
    end;

function getlocal(var c : CHAR; wflag :BOOLEAN) :INTEGER;
    begin
      while (level<>0) do
           if (fgetc(c)=ENDOF) then level := level -1;
      if (level=0) then error := getc(stdin,c,wflag);
      if (EOF(input)) then getlocal := ENDOF
      else  getlocal := 0;
    end;

procedure putlocal(c : CHAR);
    begin
        if (aux) then
          write(auxfile,c);   (* data to auxillary  file *)
        putc(stdout,c);              (* data to terminal screen *)
    end;

function getremote(var c :CHAR; wflag :BOOLEAN) :INTEGER;
    begin
        if (wait) then read(netin,c)
                  else getc(netin,c,wflag);
        if (EOF(netin)) then getremote := ENDOF
        else getremote := 0;
    end;

procedure putremote( c :CHAR);
    begin
        write(netout,c);
    end;


begin
  level := 0;              (* level counter for redirected input *)
  while (NOT done) do begin
        error := getlocal(c,nowait);
        if (error <> ENDOF) then begin
          if( c=ESC) then begin   (* enter command mode *)
                         error := getlocal(c,wait);
                         case c of
                           ESC: putremote(c); (* pass special character *)

   (* take input from *)  '<': begin  (* increase macro level *)
   (*    a new file   *)         fname := '';
                                 error := getlocal(c,wait);
 (* get filename into fname *)   while(c<>NL) do begin
                                   error := getlocal(c,wait);
                                   append(fname,c);
                                 end;
                                 level := level + 1;
    (* open new file *)          reset(macfile[level],fname);
                               end;
```

Listing 4 continued on page 163

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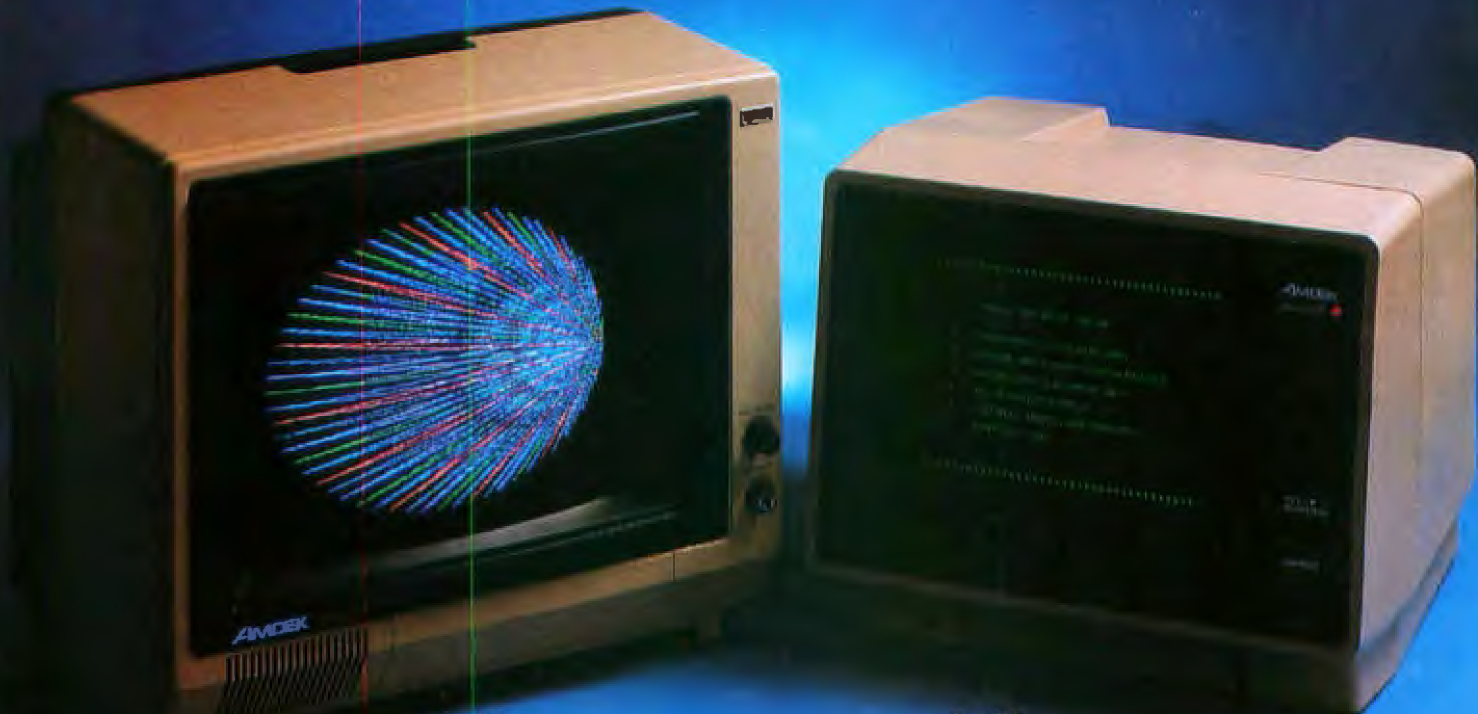
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Listing 4 continued:

```
                          '>': begin (* put output into file *)
                                 if (aux) then
                                  writeln('error: file already open.')
                                  else begin
                                    aux := true;
                                    error := getlocal(c,wait);
                                    if (c = '>') then begin
                                       app := true;
                                       error := getlocal(c,wait);
                                       end;
                                    fname := '';
      (* get filename into fname *)  while(c<>NL) do begin
                                         append(fname,c);
                                         error :=getlocal(c,wait);
                                         end;
       (* open new file or *)         if(NOT app) then rewrite(auxfile,fname)
      (* append to old file *)        else fileappend(auxfile,fname);
                                 end;
                               end;

                          '|': begin  (* close file opened by > or >> *)
                                 app := false;
                                 aux := false;
                                 close(auxfile);
                               end;

                          '.': (* terminate connection *)
                               done := true;
                        end;  (* inner case *)
                      end  (* end command mode *)
            else putremote(c);
        end; (* ENDOF error check block around case *)
       error := getremote(c,nowait);     (* characters from network *)
       if (error = 0) then putlocal(c); (* go unchanged to local    *)
   end; (* while *)
end.
```

Text continued from page 154:
NOWAIT directive to control input flow. If GETC(STDIN,C,NOWAIT) is specified, the function will come back immediately even if no character was available from the console. GETC(STDIN,C,WAIT) will wait until the user produces the needed character before returning. The integer returned by the function will show if a valid character, no character, or an end-of-file was received.

The internal designs of the GET and PUT functions depend on the system and are not shown here. Your own GETC can buffer an entire line from the terminal to allow for backspacing and editing the line before it is sent.

Some of these commands may cause a great deal of data to come back across the network. Routines which manage the system buffers will need to control the I/O, sending stop and start codes to the network as needed to prevent buffer overflow. When the input buffer is full, the host must send a pause (Control-S) to the remote to stop any more data flow until the buffer is emptied. Then it sends a resume (Control-Q) to the remote unit for more data.

The program continually looks for data going in either direction and passes it through. The only exception comes when the user types the escape character (represented as ESC), thus activating the command processor. The command processor stays active until a carriage return is received, indicating the end of the command. The following commands are supported by my TRANSLUCID module:

- ESC<*filename* (carriage return). Take input characters from *filename* instead of the console. When all the characters in *filename* have been read, return control to the console. The sequence ECS<*filename* (carriage return) can occur inside a file as well as from the keyboard. The version in this article will support ten levels of nesting and can be easily modified for any number of levels.
- ESC>*filename* (carriage return). Send output from the network to the file specified by *filename* as well as to the terminal screen.
- ESC>>*filename* (carriage return). Append output from the network to *filename* as above.
- ESC | (carriage return). Close out-

put file specified by previous > or >> command. Note that only one output file can be opened at a time.

• ESC . Terminate the program. If TRANSLUCID is used as a procedure, this will return to the next highest level.

Any character can be used for the ESC or escape sequence by changing the constant declaration at the beginning of TRANSLUCID. This character can be passed to the network by typing it twice (only one copy gets through). I used the character ESC (hexadecimal 1B).

TRANSACT

The program to conduct the transaction is directed by a data structure which describes the transaction. For all transactions, the program will determine what is to be done from this structure and execute commands on the remote and local system. It will move, copy, or delete files across the link. The data structure is shown in figure 3.

The number of data types determines the number of pending transactions a system can have. Following is a description of the variables in TRAN_TYPE:

• ACTION: one of five ACTIONS supported for moving files between systems and executing commands on the remote system. These are detailed in the TRANSACT source code.

• SYSTEM_ID: an integer identifying the remote unit.

• T_PACKET: the name of the file which contains the packet. The packet consists of commands to the transaction processor, commands to the local and remote system, and data (or the names of files containing data).

• ACTIVE: a flag set if this transaction is the currently active one. The flag is checked by the WATCHDOG timer to see if a transaction was active and timed out.

```
tran_type    =  RECORD
                   action       : INTEGER;
                   system_id    : INTEGER;
                   t_packet     : file_name;
                   active       : BOOLEAN;
                END;

var    tran_table : ARRAY[20] OF tran_type;
```

Figure 3: *Definition of the transaction table, represented in Pascal.*

This data structure will be used by the three main routines: AGENDA, which sets up the transaction; TRANSACT, the transaction processor which carries out the actual work; and WATCHDOG.

TRANSACT (see listing 5) needs the primitive commands — OPEN, CLOSE, DELETE, PRINT, and APPEND — for each remote system with which it will communicate. When the transaction processor wants to read a file on the remote system, it must look in a file called COMMANDS for the command to PRINT a file on that system. The proper command is extracted from this file by specifying which command is desired and the system identifier. The algorithm appears in the procedure COMMAND of TRANSACT.

The execution of an arbitrary command on the remote system is handled by case five in TRANSACT. This routine uses another scheme for synchronizing with the prompt. When a character is received from the network, it is put in a string called CBUFFER. When CBUFFER is the same length as the expected prompt and a new character is received, CBUFFER is sent along to the output, and the new character becomes the first one in the buffer. If the network stops sending characters, the routine will time out. The last thing in

Text continued on page 174

Listing 5: The module that determines the overall behavior of the network node, according to "instructions" contained in a transaction table data base.

```
module transact;
      (*****************************************************************)
      (*                                                               *)
      (* Transact is the transaction processor. Given a record of     *)
      (* a tran_type, it executes the specified transaction.           *)
      (* The following actions are possible:                           *)
      (*    1  move a new file to the remote system                    *)
      (*    2  copy over a file on the remote system                   *)
      (*    3  move a new file from the remote system                  *)
      (*    4  copy over a file from the remote system                 *)
      (*    5  execute an arbitrary command on the remote system       *)
      (*                                                               *)
      (*   Basic commands executable on remote system are              *)
      (*   1: OPEN FILE    2: CLOSE FILE    3: DELETE FILE             *)
      (*   4: PRINT FILE   5: APPEND TO FILE                           *)
      (*                                                               *)
      (*             Copyright  1981  by Peter Reintjes                *)
      (*                                                               *)
      (*****************************************************************)

type
        file_name     = ARRAY [1..20] OF CHAR;

        tran_type     = RECORD
                          action       : INTEGER;
                          system_id    : INTEGER;
                          t_packet     : file_name;
                          active       : BOOLEAN;
                        END;

        buffer        = ARRAY [0..2047] OF CHAR;
        buf           = @buffer;
        prom          = STRING 50;

external function getremote(channel: CHARS;
                            var  c :CHAR;
                            wflag  :BOOLEAN):   INTEGER;
external procedure prompt( pmt : prom;
                           bptr: buf;
                           off, len : INTEGER): INTEGER;

 const
        wait        =  true;
        nowait      =  false;
        TIMEOUT     =  500;

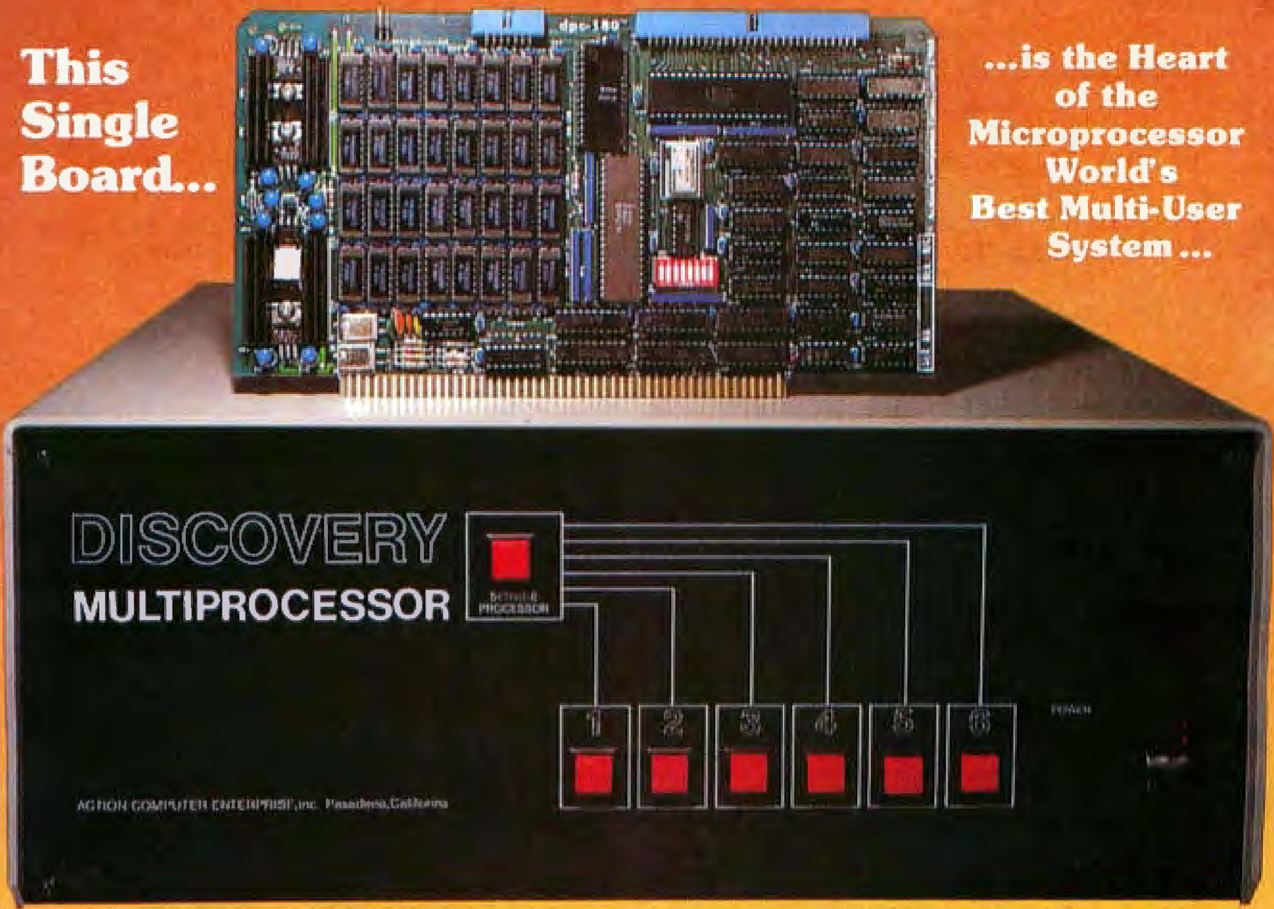
 var
       i, j, n       : INTEGER;
       c             : CHAR;
       cbuffer       : STRING 100;
       time, error   : INTEGER;
       exit          : BOOLEAN;
       failed        : BOOLEAN;
       command_file  : FILE OF CHAR;
       tran          : tran_type;
localname,remotename : file_name;
   tempname, newname : file_name;

function command( system, cmd : INTEGER) : STRING 100;

    var
```

Listing 5 continued on page 168

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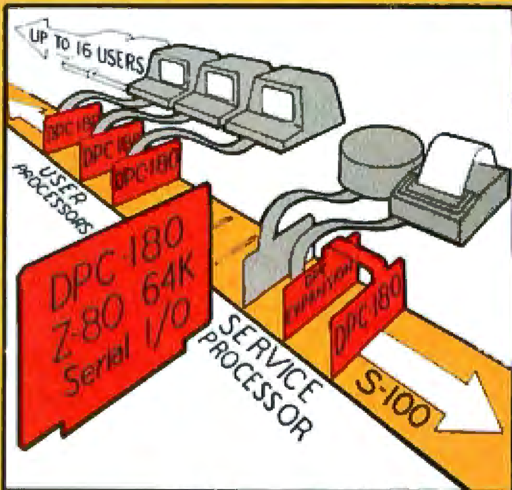
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Listing 5 continued:

```
        i, n    : INTEGER;
        cstring : STRING 100;

begin
      (* The file contains the system name and five  commands   *)
      (* for each system. If we want the third command for the  *)
      (* fourth system we need to get the 22nd line of the file *)
      (* ( system # - 1 ) * 6  + command # + 1                  *)

      n :=  (system - 1) * 6  + cmd + 1 ;

      for i := 1 to n do read(command_file, cstring);
      command := cstring;
end;


   (************** MOVERL **************************)
   (* move a file from the remote system to local *)

function moverl( r_name, l_name :file_name ): INTEGER;

var
       lf   : FILE OF CHAR;
   result   : INTEGER;

begin
        rewrite(lf,l_name);  (* create local file *)

   (* get command to print a  file  from the remote  *)
   (* write out the command followed by the filename *)
        write(network, command, r_name);

        while ( time < TIMEOUT ) do begin
               error := getremote(c,nowait);
               if (error = 0) then time := 0;
               write(lf,c);
        end;

        result := prompt(pmt,bufptr,offset-length(pmt),length);
    (* the prompt should be the last thing in the buffer *)
        if ( result = offset + length ) then moverl := 0
        else moverl := -1;
end;


   (****************** MOVELR *************************)
   (* move a file from the local system to the remote *)

function movelr( l_name, r_name :file_name; sid :INTEGER): INTEGER;

    var
        cstring : STRING 100;
        lf      : FILE OF CHAR;
        result  : INTEGER;

begin
        reset(lf,l_name);  (* open local file *)

   (* get command for opening a file on remote  *)
        cstring := command(sid,1);
        write(network, cstring, r_name);
```

Listing 5 continued on page 170

```
        while (NOT EOF(lf)) do begin
                read(lf,c);
                write(netout,c);
        end;
    (* get command for closing file on remote *)
        cstring := command(sid,2);
        write(network,cstring);

(* after network has settled, check for a normal system prompt *)
(* Note we haven't read characters from the input buffer yet   *)
(* These are global variables.                                 *)

        result := prompt(pmt,bufptr,off,len);

    (* the prompt should be the last thing in the buffer *)
        if ( result = off + len ) then movelr := 0
        else movelr := -1;
end;


entry function transact (var transaction:tran_type):INTEGER;

begin

   reset(command_file,'commands');

   with transaction do begin
        active := true;
        reset(packet, t_packet); (* open instruction file *)

        case action of

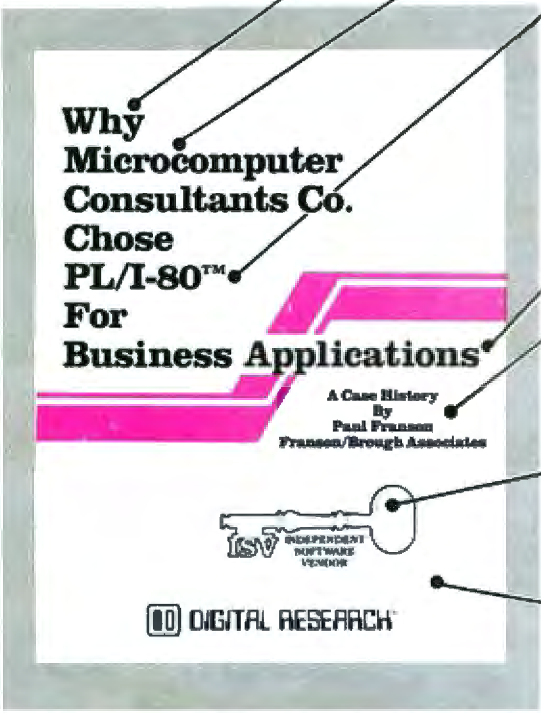
            1: begin  (* move a new file to remote *)

                read(packet,localname); (* name of  local  file   *)
                read(packet,remotename);(* name of file on remote *)
                error := movelr(localname,remotename);
                if (error <> 0) then begin
                     rem_delete(remotename);
                     failed := true;
                     end;
               end;

            2: begin  (* copy already existing file to remote *)
                read(packet,localname); (* name of  local  file   *)
                read(packet,remotename);(* name of file on remote *)
                tempname := remotename;
                append(tempname,'.temp');
                error := movelr(localname,tempname,system_id);
                if (error = 0) then begin
                        rem_delete(remotename);
                        rem_rename(tempname,remotename);
                        end
                else begin
                     rem_delete(tempname);
                     failed := true;
                     end;
               end;
```

Listing 5 continued on page 172

PL/I-80™: Not for beginners*

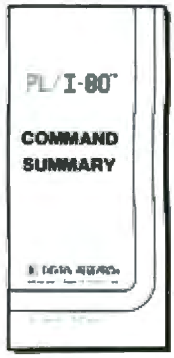


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- **Specific examples** of PL/I-80's speed, memory conservation, error checking, and control in the business environment are cited.
- **In a candid interview,** Mr. Charles Russell, MC's president, discusses his professional programming needs.

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Listing 5 continued:

```
          3: begin  (* move a new file from remote *)

               read(packet,newname); (* name of  local  file   *)
               read(packet,remotename);(* name of file on remote *)
               error := moverl(remotename,newname,system_id);
               if (error <> 0) then begin
                    delete(newname);
                    failed := true;
                    end;
             end;

          4: begin  (* copy over local file from remote *)
               read(packet,localname); (* name of  local  file   *)
               read(packet,remotename);(* name of file on remote *)
               tempname := localname ;
               append(tempname,'.temp');
               error := moverl(remotename,tempname);
               if (error = 0) then begin
                       delete(localname);
                       rename(tempname,localname);
                       end
               else begin
                    delete(tempname);
                    failed := true;
                    end;
             end;

          5: begin  (* execute a command on the remote *)
                rewrite(outfile,'cmd.temp');
                read(packet,command);  (* get command from packet *)
                write(netout,command); (* write it out to network *)
                while (time < TIMEOUT) do begin
                       error := getremote(c,nowait);
                       if (error = 0) then begin
                           time := 0;     (* reset clock *)
                           if (length(cbuffer)=length(pmt)) then begin
(* we buffer a  string  *)            write(outfile,cbuffer);
(* the length of prompt *)            append(cbuffer,c);
                                      end;
(* do we see the prompt?*)
                           if (cbuffer=pmt) then failed := false
                                            else failed := true;
                       end
                       else time := time + 1;

                end;

        (* Timed out in the middle of the transfer *)
                if  (failed) then transact := -1
        (* If the last thing we saw was the prompt *)
        (* then it worked ok.                      *)
                             else transact :=  0;

             end;  (* of case 5 *)
      end (* of case *)

  end;
```

Text continued from page 164:

CBUFFER after the routine times out should be the prompt from the system indicating that the operation is complete. You do not usually want the prompt passed along to the output file because it is not really part of the network's response to your command.

Possible Enhancements

Several other functions may be needed on the local processor, including:

- Monitor space usage on the local system, and terminate network activity if the local storage is dwindling.
- Buffer input and output to keep track of data moving in all directions and control its flow. The goal is to avoid any loss of data because of speed differential or overflow in the interface.
- Archive data to keep track of the large amount of data (and storage) available on the network. You will probably need some form of off-line storage, either local or out in the network. Systems frequently run out of file space a few months after a mail or news system is installed.

Both the high-level user interface and the low-level system interface have been sketched briefly here. These are user- and system-dependent and therefore not portable, but they will help you develop a protocol-free network on most systems.

Some preprocessing of files can cut down on the network interaction time. It is important to order the transactions by SYSTEM_ID so that all transactions for a given system will be made on the same phone call. If there is no system response for the first transaction, the others should not be attempted. A Huffman encoding can compress text files by as much as two-thirds and random data by 20 to 30 percent. If you are sending large files over long distance, this could mean significant savings.

Making the files self-loading would be an improvement. This can be done by a separate utility; the actual transaction processor could then be much simpler than the one I described.

Breaking up large files into standard packet sizes and adding checksums can reduce the amount of retransmission due to a dropped bit; the optimal packet size will depend on the modem speed and the quality of the connection. Other forms of preprocessing can further enhance your network system. With the proper set of tools, these variations can be explored with much less effort.

The problems of conversations between computers are greatly simplified if you install programs on both systems which support the same protocol. However, my proposed system is sufficiently general to be used when you have little or no control over the software running on the remote computer, and your machine must log on and behave like a human user.

Even if every remote site has computer-protocol facilities, they are not likely to support the same protocol. Modules like the ones I have presented allow you to build a generalized system to converse with all such services.

Future Network Developments

Some trends that will make a flexible network philosophy important in the future already are evident today.

The telephone, for example, will offer increased bandwidth, possibly at less expense. Modem-based networks will be at least as important as hardwired configurations. Greater processing power and storage will be available on a network node as more powerful CPUs and memory systems are developed. More network services with a wide variety of protocols will be available, and we have no reason to be optimistic about standardization.

The possibilities for a system not tied to a specific protocol are almost endless. High-level programs can be built for a mail or source management system. You can write utilities that do everything from answering your electronic mail while you're away, to synchronizing the system clock with a weekly call to a computer at the National Bureau of Standards.

In addition, the modularity I've encouraged will allow you to make enhancements without losing your investment in previous software. This characteristic could mean the difference between a networking system which withstands (or changes to meet) the test of time, and one that will be abandoned in the next generation of hardware and software. ■

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A Simple Implementation of Multitasking

Wendell Brown
8 Reynolds St
Oneonta NY 13820

Multitasking software makes multiuser systems possible and permits the division of complex programs into smaller segments. Writing such software requires an understanding of the basic principles of synchronization (ie: executing the right program or using the right stack at the right time) and a knowledge of resource sharing (using such computer resources as printers, keyboards, memory, and central processing units).

This article explains how to write multitasking software for microprocessors. I will first discuss the theory of multitasking, then give a simple example of one of the better implementations, called SLEEP (originated by APh Technological Consulting, a firm located in Pasadena, California).

Multitasking has many possible ap plications. A few examples are: handling communications between a computer and more than one terminal; programming devices like thermostats, burglar alarms, and light controllers; having your computer play your favorite adventure game and regulate room temperature at the same time; and connecting two terminals to your computer so that each can run a different BASIC program at the same time.

The last example is, of course, timesharing—a well-known and complex variety of multitasking.

Not all programs can or should use multitasking, but many applications are naturals for this approach. Keyboard polling (watching the keyboard to see if a key is pressed) and printer driving (telling a printer to do something) can each be written as a closed loop, and then, during execution, made to seem as if they are running simultaneously.

In addition to making your computer more versatile and useful, learning to write multitasking software has other benefits. For one thing, it forces you to organize your programs. For another, the multitasking approach lets you break large programs into smaller, more manageable pieces. You can then assign the writing to several different persons, and the author of one piece will not need to know how the other pieces work. Of course, each writer must know the bounds of his or her assignment, and must understand the relationships between the pieces. Dividing programs this way not only helps you complete a large project faster, but also simplifies debugging, as it is much easier to debug small pieces of code than one large program.

Methods of Multitasking

Though simple in theory, several of the methods of achieving multitasking are tough to implement. Others can be implemented by means of straightforward programming. Let's examine a few methods, choose one, and focus on it.

Perhaps the most familiar way to complete a series of tasks is to simply line them up and perform them in succession. In BASIC we could do this by writing a set of subroutines, and then have a master loop to call each of the subroutines in turn (sometimes called the "hen-and piglets" method, see listing 1). A similar structure can also be used in a machine-code program.

One problem with the hen-and-piglets method is that subroutines are not closed; there is no guarantee that the piglet will ever run to completion. Thus, each subroutine must have a RETURN statement at the end. While this does not pose a difficulty for simple routines, it can be cumbersome in larger programs where we might want to use a routine written by someone else. In that case we might have trouble adding the RETURN statement in the proper place.

Another problem with this method is that each routine cannot have its own stack. Although it isn't a problem in BASIC, it can be a big problem in machine code; sometimes a routine needs its own stack, or the stack is too short, or we don't want to disturb the data far up on the stack.

But the hen-and-piglets method does work well for simple programs. The method requires no programming overhead, and, furthermore, it is easy to add another routine in the loop. To do so, simply insert a CALL statement in the control loop where

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Wendell Brown, a Hughes Aircraft Company Bachelor of Science scholar, is studying Computer Science at Cornell University. Among his interests are robotics, computer graphics, and speech.

Acknowledgments

I would like to thank Paul Moster, of Cornell University's low-temperature group, for helping me write the HPIB software.

the other subroutines have their CALL statements.

SLEEP

Another way to accomplish multitasking is a method called SLEEP. We will focus on this method, in which each routine has a closed loop and does not return at the end. Instead, the statement CALL SLEEP is inserted anywhere in the closed loop of the routine. In effect, the SLEEP routine replaces the main CALL loop in the hen-and-piglets method. Although implementation is tricky, SLEEP is a unique and useful tool.

Listing 1: *A simple BASIC program illustrating the "hen-and-piglets" method of implementing multitasking. A master loop starting at line 20 calls each of the subroutines—Huey, Duey, and Luey—in turn.*

```
LIST

10 REM THIS PROGRAM IS AN EXAMPLE OF THE HEN AND PIGLETS METHOD
20 REM HERE IS THE LOOP
30 GOSUB 100
40 GOSUB 200
50 GOSUB 300
60 GOTO 20
100 REM ****** HUEY *******
110 PRINT "H";
120 RETURN
200 REM ****** DUEY *******
210 PRINT "D";
220 RETURN
300 REM ****** LUEY *******
310 PRINT "L";
320 RETURN
READY


RUN
HDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLHDLH
```

We can use SLEEP to multitask a series of routines so that they all appear to run at the same time. We'll explore the general idea, then look at a specific example.

The SLEEP routine essentially simulates a complex computed GOTO statement. It first determines which program called it, then calculates which program to jump to next. The programs are serviced (branched to) in a circular fashion, so that each program is executed once every cycle. The only requirement is that each program *must* call SLEEP to give the other programs a chance to run.

When a program calls SLEEP, it is, in effect, giving SLEEP control of the processor; SLEEP, in turn, passes control on to the next program. If any of the programs are "time-critical" (ie: must be run within a given time period), then we must be sure that no one routine dominates the processor. Specifically, we must place the CALL SLEEP statement where it will be executed often in the loop of each pro-

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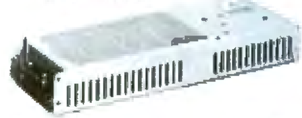
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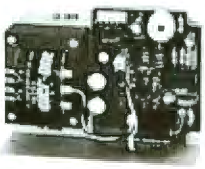


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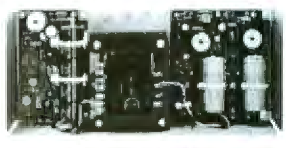
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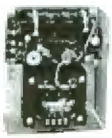
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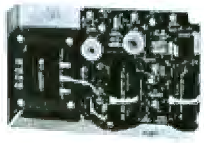
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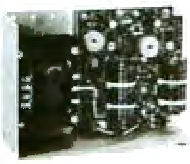
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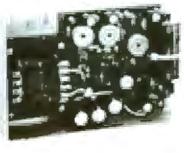
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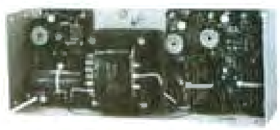
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gram. Further, we must write a small program (about 30 bytes) to initialize each program's stack.

Think of each program as having its own microprocessor. Each program has an individual stack and is written as a closed loop in order to allow continuous operation. All programs share the same memory, which has both advantages and disadvantages. Programs can pass data among themselves by using this shared memory as a common data area. One program can write to a predetermined memory byte, while another reads this byte.

The disadvantage of shared memory is that sometimes it is convenient for each program to have its own unique memory. For example, if we wanted to time-share a BASIC in order to run more than one BASIC program at a time, then we would have to provide enough memory to hold both programs. Since most BASICs aren't relocatable (having a unique address where they must be loaded and executed), we can hold only one copy of BASIC in memory at one time. And since most BASICs use a unique memory area to store a single program, we have to use more tricks to make a multiprogram BASIC run. (More on this later.)

Listing 2: *SNOOZE, a 6502 assembly-language program showing the SLEEP method of implementing multitasking. Three separate programs—Huey, Duey, and Luey—each contain a CALL SLEEP statement. The SLEEP routine branches to the programs in a cyclical fashion. Each program is executed once every cycle, and all appear to run simultaneously.*

```
          TITLE     "SNOOZE"
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;         THIS SIMPLE EXAMPLE SHOWS HOW EASY IT IS TO IMPLEMENT A MULTI-
;TASKED MACHINE.  THE THREE SEPARATE, INDEPENDENT PROGRAMS WHICH APPEAR
;TO RUN SIMULTANEOUSLY ARE:  HUEY, DUEY, AND LUEY.  HUEY PRINTS A "H" TO
;THE TERMINAL, DUEY A "D", AND LUEY A "L".
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

          ZSECT
TTYOUT    =:        $FFEF                    ;ADDRESS OF TTYOUT ROUTINE
JOBS      =         3                        ;NUMBER OF JOBS
STACKLEN  =         20                       ;LENGTH OF EACH JOB'S STACK
SPTABLE   :         BLOCK     JOBS           ;ARRAY OF STACK ADDRESSES
CURJOB    :         BLOCK     1              ;NUMBER OF THE CURRENT JOB RUNNING
STACKAREA:
          BLOCK     STACKLEN                 ;EACH JOB HAS ITS OWN STACK
HSTACK    :                                  ;IN THE 6502, THE STACKS "GROW" UPWARD
          BLOCK     STACKLEN
DSTACK    :
          BLOCK     STACKLEN
LSTACK    :

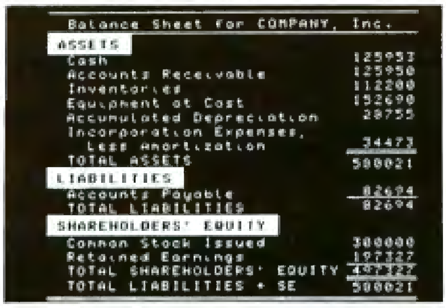
          PSECT
STARTUP:                                     ;BRANCH HERE TO START EXECUTION
          SEI                                ;DISABLE INTERRUPTS
          CLD                                ;CLEAR DECIMAL MODE
STKINIT:  LDX       #LSB(LSTACK-1)           ;INITIALIZE LUEY'S STACK
          TXS
          LDA       #MSB(LUEY-1)             ;PLACE LUEY'S ADDRESS ON LUEY'S STACK
          PHA
          LDA       #LSB(LUEY-1)
          PHA
          LDA       #LSB(LSTACK-3)
          STA       SPTABLE+1

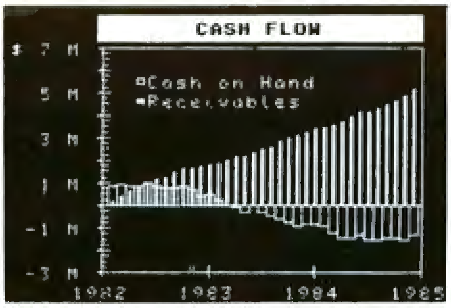
          LDX       #LSB(DSTACK-1)           ;INITIALIZE DUEY'S STACK
          TXS
          LDA       #MSB(DUEY-1)             ;PLACE DUEY'S ADDRESS ON DUEY'S STACK
          PHA
          LDA       # LSB(DUEY-1)
          PHA
          LDA       #LSB(DSTACK-3)
          STA       SPTABLE+2

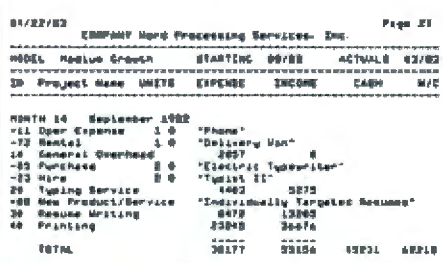
          LDX       # LSB(HSTACK-1)          ;CURRENT STACK IS HUEY'S STACK
          TXS
          LDA       #0                       ;PREPARE TO RUN JOB #0 (HUEY)
          STA       CURJOB

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;         THAT IS ALL THAT HAS TO BE DONE TO INITIALIZE THE MACHINE.
;NOW SIMPLY JUMP TO JOB #0 (WHICH HAPPENS TO BE HUEY IN THIS EXAMPLE),
;AND ALL THREE MACHINES WILL APPARENTLY RUN SIMULTANEOUSLY.
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
          JMP       HUEY
```

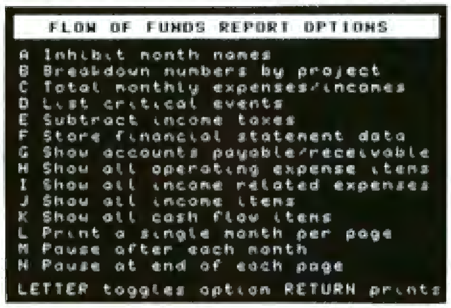
Listing 2 continued on page 182













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Listing 2 continued:

```
;AND NOW THE THREE PROGRAMS

HUEY:   LDA     #"H"            ;PROGRAM HUEY
        JSR     TTYOUT          ;PRINT A "H" AT THE TERMINAL
        JSR     SLEEP
        JMP     HUEY

DUEY:   LDA     #"D"            ;PROGRAM DUEY
        JSR     TTYOUT          ;PRINT A "D" AT THE TERMINAL
        JSR     SLEEP
        JMP     DUEY

LUEY:   LDA     #"L"            ;PROGRAM LUEY
        JSR     TTYOUT          ;PRINT A "L" AT THE TERMINAL
        JSR     SLEEP
        JMP     LUEY


SLEEP:  TSX                     ;ROUTINE TO "PUT TO SLEEP" THE
        LDY     CURJOB          ;CURRENT JOB, AND "AWAKEN" THE NEXT
        STX     SPTABLE,Y       ;JOB.  SLEEP CAN BE PLACED ANYWHERE.
        INY
        CPY     #JOBS           ;IF REACHED THE LAST JOB, THEN START
        BNE     NOZERO          ;EXECUTING THE FIRST JOB AGAIN
        LDY     #0
NOZERO: STY     CURJOB
        LDX     SPTABLE,Y
        TXS
        RTS


;IF YOU WANT TO SAVE YOUR CPU REGISTERS BEFORE A PROGRAM IS PUT TO SLEEP,
;THEN CALL SLEEPR INSTEAD OF SLEEP.

SLEEPR: PHP
        PHA                     ;SAVE REGISTERS ON STACK
        TXA
        PHA
        TYA
        PHA
        JSR     SLEEP           ;SLEEP NOW THAT REGISTERS ARE SAVED
        PLA
        TAY                     ;AWAKEN, RECALL REGISTERS FROM STACK
        PLA
        TAX
        PLA
        PLP
        RTS
```

Example: Using SLEEP

Let's look at the program SNOOZE (see listing 2). Written in 6502 assembly language, SNOOZE is a simple example of SLEEP that shows how to multitask the three functions Huey, Duey, and Luey. SNOOZE can be broken down into three main areas: initialization; the subprograms Huey, Duey, and Luey; and SLEEP.

Although in this example the initialization segment is larger than the program segment, this is not always the case. The purpose of initialization is to set up the stack areas for the three subprograms. We'll follow the initialization segment from the top down.

The ZSECT merely tells the assembler to place the following code in page zero (bytes 0 to 255). With the 6502 microprocessor, the stack pointer can point to memory only within the first page. TTYOUT is a routine (not shown) which prints the contents of the accumulator to the terminal. This routine varies from one computer system to the next.

JOBS signifies the number of jobs that we want to multitask; in this case, there are three (Huey, Duey, and Luey). STACKLEN signifies the length of each program's stack. SPTABLE is a table of length JOBS, to be used exactly like a stack pointer. Each job has its own stack pointer, which is stored in the table when one particular job is asleep. CURJOB contains the number of the job currently running. In this example, CURJOB may have only the values 0 (which means Huey is running), 1 (Luey), or 2 (Duey).

STACKAREA is JOBS × STACKLEN bytes long (3 × 20 = 60 in this

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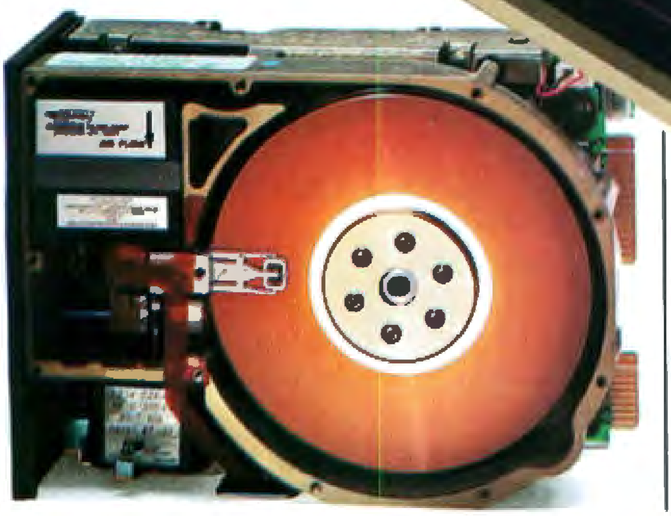
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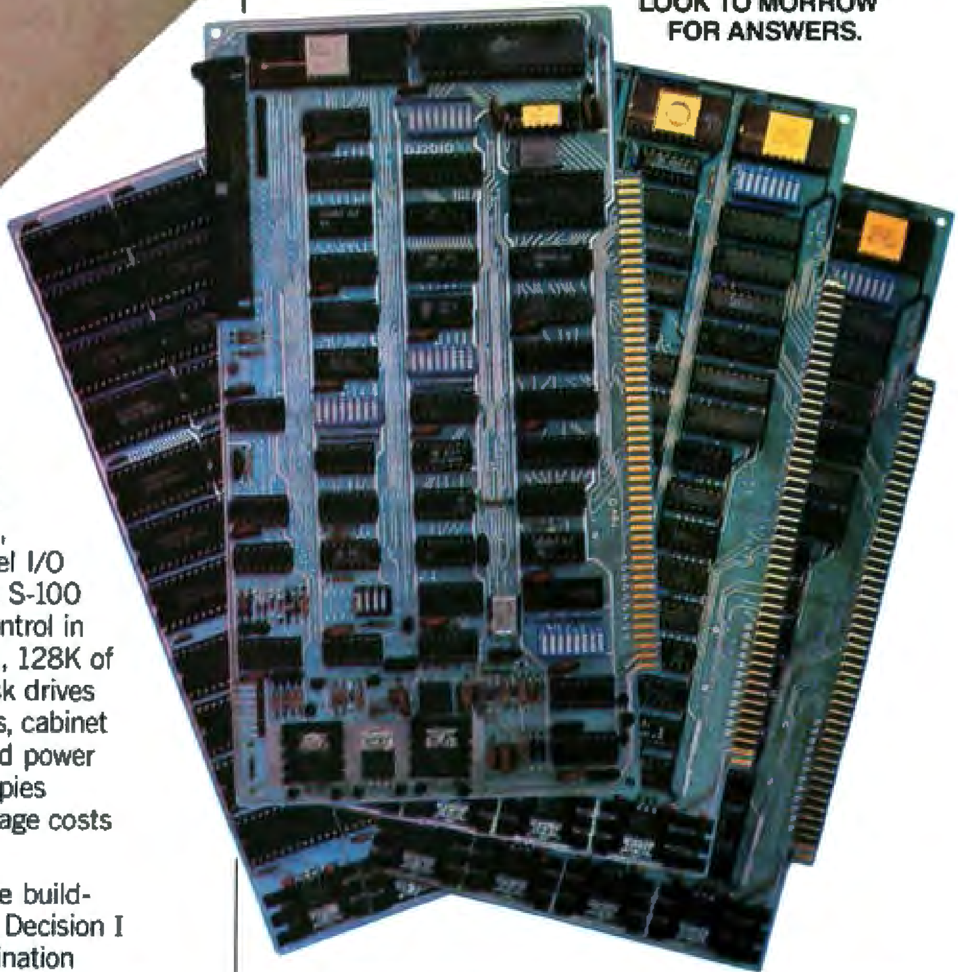


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example), and houses the actual stack for each program. Since in the 6502 the stack "grow" upward (toward page zero), each program's stack has a label pointing to the bottom of the stack. As a stack is used, the pointer steps along the stack.

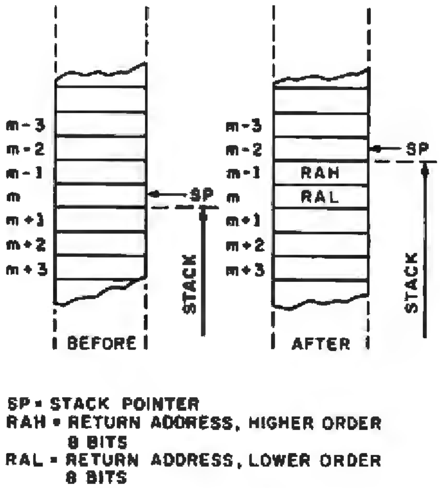


Figure 1: *Saving a return address in the stack during execution of the SNOOZE program (shown in listing 2). Whenever a machine-level subroutine is called, the microprocessor forces the return address onto the stack. Later, when an RTS (return) instruction is executed, the microprocessor retrieves the return address from the stack and puts it into the program counter. As a result, executing an RTS instruction causes the microprocessor to branch to the start of the subroutine.*

Now that we have defined variables and stacks in page zero, we must fill those variables with meaningful values. PSECT tells the assembler that the following is program code, to be placed somewhere other than page zero. Label START-UP is the place we'll branch to in order to begin the programs.

Before Huey, Duey, and Luey run, however, we must complete initialization. SEI disables the 6502 interrupts—just a precaution in case we forget to disable interrupts after the last program. CLD clears the 6502 decimal mode, and is another general precaution, rather than a unique requirement of multitasking.

The next twenty instructions lead to one goal: to fill the bottom two bytes of each stack with the starting address of the program so that we can

fake a jump instruction with a return instruction. When we call a machine-level subroutine, the microprocessor forces the return address onto the stack, and jumps to the subroutine (see figure 1). The opposite (popping the stack, and jumping to the return address of the function which originally called the subroutine) occurs when the microprocessor executes a return from the subroutine (RTS in 6502 assembly language).

Thus, if we put the starting address of the program on the stack, then execute an RTS, the microprocessor branches to the start of the program. The entire operation is simple, but lets us perform several clever tricks.

Starting at STKINIT, we initialize the stack areas. #LSB is an assembler function that extracts the LSB (least-significant byte) from the value in parentheses. TXS transfers the value from the X register (which contains Luey's stack pointer) to the stack-pointer register. Similar to #LSB, #MSB is an assembler function that extracts the MSB (most-significant byte).

In the next several instructions, we will place two bytes, which are the starting address of program Luey, on the stack. PHA pushes the value of the accumulator onto the stack. We then store the value of the stack-pointer register into the SPTABLE array offset by 1 (remember how CURJOB's value of 1 means Luey is running?). Next, we initialize Duey's stack exactly as we did Luey's, except at the end we store the stack pointer into SPTABLE with an offset of 2 instead of 1. We now set the stack-pointer register to Huey's stack area, since Huey will run first (see figure 2). We must also set CURJOB to signify that Huey will be running (CURJOB=0). Finally, we jump to Huey,

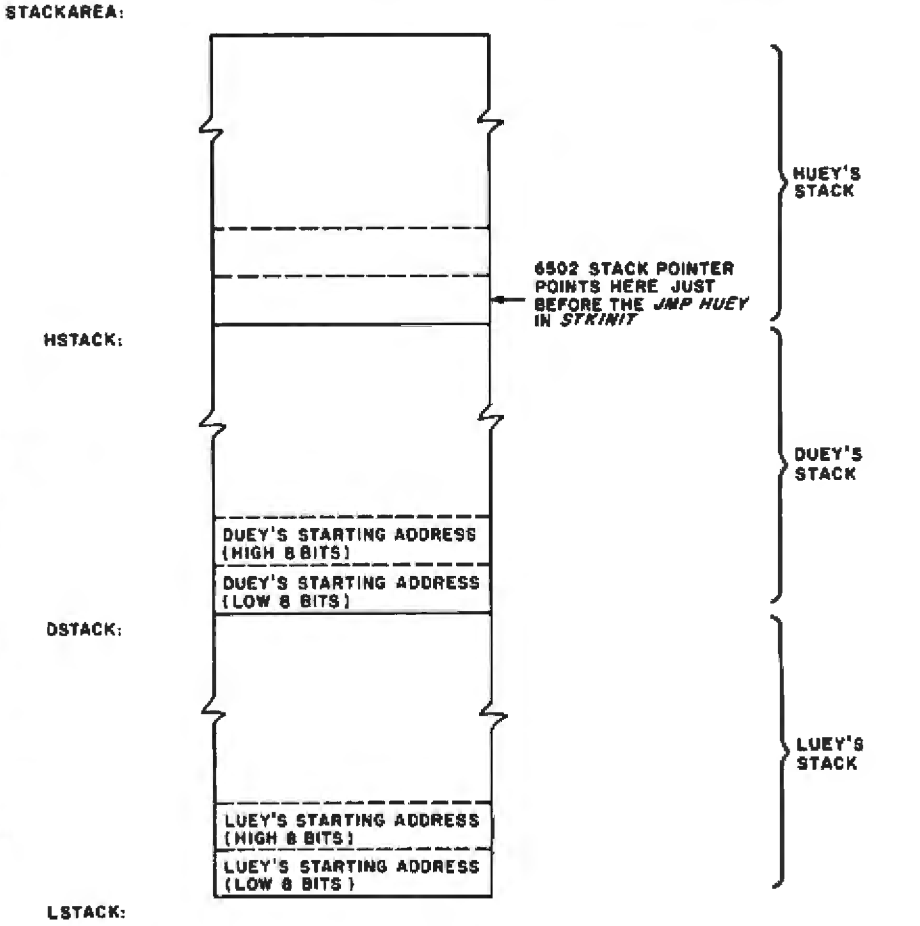


Figure 2: *The state of the stack area immediately before the JMP HUEY instruction in the STKINIT subroutine of the SNOOZE program (see listing 2). STKINIT initializes the stack areas. Since the stack-pointer register is now pointing to Huey's stack area, Huey will run before the subroutines Duey and Luey.*

and whiz...everything is up and running.

Each of the programs Huey, Duey, and Luey prints the first letter of its name to the terminal. LDA is a load accumulator immediate, and loads the accumulator with the character "H," "L," or "D," depending on which program is running. JSR (jump subroutine) TTYOUT calls the routine that prints the value of the accumulator to the terminal. JSR SLEEP calls the sleep routine. JMP HUEY completes the program by jumping to the start of the program. Notice how each program is a closed loop. Programs Duey and Luey are exactly like Huey, except for the characters they print.

The SLEEP routine is the most magical of all. SLEEP first uses the TSX instruction to save the value of the stack-pointer register in the X register. LDY loads the value of CURJOB into the Y register. INY increments the Y register. The CPY instruction compares the incremented Y register against JOBS (containing the number of total jobs, three in our example) to see if we are at the end of a cycle.

If not, BNE branches to NOZERO if the incremented Y register minus JOBS is not zero. However, if we have reached the end of the cycle, then the LDY instruction loads zero into the Y register. At label NOZERO, the contents of the Y register are stored into location CURJOB, reflecting the job to be run next. The LDX instruction loads a stack-pointer value from SPTABLE, offset by the Y register (which equals CURJOB) into the X register. The TXS instruction then transfers the value of the X register into the stack-pointer register. Finally, an RTS effectively forces a branch to the program indicated by CURJOB. SLEEP, while a little tricky, is short and sweet.

SLEEPR can be called instead of SLEEP if we want to preserve the contents of our CPU registers before going to sleep. SLEEPR simply pushes the contents of all registers onto the program's stack, then calls SLEEP. After returning from SLEEP (and allowing the other programs to run), SLEEPR restores the CPU registers by popping them back off the stack.

The three programs won't actually run simultaneously, but they will run in such rapid succession that, for most purposes, they will appear to be running at once. When we execute SNOOZE, the terminal instantly displays:

HLDHLDHLDHLDHLDHLDHLD...

Other Applications

There are, of course, many uses for multitasking. Timeshared BASICS for multiple users or for single users with multiple programs are one possibility. Real-time (ie: the program runs and interacts with external events), multiuser dungeon games would appeal to the fantasy-minded. For control applications, we could assign a single microprocessor the duties of monitoring many instruments, each instrument having its own subprogram.

For complex operating systems, we could assign printer spooling (various programs writing to the same



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printer), keyboard polling, and floppy-disk management, to their own multitasked programs. Music synthesizers could produce multiple tones from software designed for single tones.

At Cornell University's low-temperature physics group, we have written multitasking software for the 6502 that implements the HPIB functions (Hewlett-Packard Instrument Bus, also known as IEEE standard 1978-488). This standardized bus is used not only in laboratory instruments, but also in the Commodore PET computer as a peripheral port. While it is possible to program all these routines using other software techniques, the use of SLEEP may simplify conception and implementation.

Let's take a closer look at how we might multiprogram a standard BASIC. First, we must have enough free memory in our system to hold at least two different BASIC programs. The best method of multitasking BASICs involves updating BASICs pointers to the start of the program memory, variable areas, etc. However, this method is complex and you must know where these pointers reside in memory for your particular BASIC. Let's consider a simpler but less efficient method.

The general scheme is to swap out the BASIC program, variables, and line counter (the value indicating the next BASIC line to be executed), and then swap in the next program's program, variables, and line counter. The addresses vary depending on which BASIC we use. Since most computers have only one keyboard and display, we must have a way to indicate which program we wish to communicate with at any given time. To accomplish this, we must choose a specific keyboard command. Finally, we must decide how often we want the computer to swap the programs in and out. We could do this in software, similar to SNOOZE, by calling SWAP occasionally. Or we could force swapping by pulling a hardware interrupt.

A hardware interrupt is, basically, a method of forcing the execution of specific software when the proper signal is sent on the interrupt line. We could connect a timing device to the interrupt line, forcing a SWAP routine to swap BASIC programs at every clock period of our timer. SNOOZE could also be implemented using this interrupt approach. However, the requirement of such interrupt hardware is a slight disadvantage.

Now that you have seen the structure of the SLEEP method of multitasking, you may want to try writing your own multitasking software. For the small-computer owner who thinks he is outgrowing his system, the convenience and added power of resource sharing can be a strong incentive to implement multitasking. All too often, our first reaction to a strain on resources is to buy a new system. But a better reaction might be to write such software. The SLEEP method may help your present computer system perform beyond your expectations. If your system seems overburdened and worn out, maybe it just needs a little SLEEP.■


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Tree Searching

Part 2: Heuristic Techniques

Gregg Williams, Senior Editor

Exhaustive tree searches, for reasons that will be explained later, will *eventually* arrive at an optimal path between the start node S and the goal node closest to S. The exponential expansion of many problems can outgrow the memory and speed capabilities of even the largest computers; because of this, methods have been developed that selectively limit the number of nodes expanded but still include those nodes that lead to the closest goal node. These *heuristic techniques* work by extracting information from the node and using it to determine the likelihood of being on the best path to a goal node.

In this article we will be concerned with two types of heuristic techniques, *admissible* and *nonadmissible*, and will experiment with them, using the BASIC program given in the first part of this article. (See "Tree Searching, Part 1: Basic Techniques," September 1981 BYTE, page 72.)

Admissible-Algorithm Theory

One method of searching a problem tree is to order the list of open nodes by giving each node a numeric value and having the program choose the node with the lowest value for immediate expansion (an approach used in the SEARCH program in Part 1 of this article). Although this method can be used with any ordering that produces a successful search, a mild restriction on the nature of the ordering produces a search algorithm that is guaranteed to find both a goal node and the optimal goal node—that is, the goal node that has the smallest *cost* associated with it. This algorithm is called *admissible*.

Refer to the partial tree shown in figure 1. (Here we will assume that the paths from S to n and from n to G are the shortest paths available.) Define $g(n)$ as the shortest path from the start node S to node n; define $h(n)$ as the shortest path from n to the *closest* goal node G. Then

$$f(n) = g(n) + h(n)$$

is the cost of the optimal path to a goal node, *given that the solution must go through node n*. (If no such path exists, the cost is said to be undefined; with a program, the appropriate cost variable would be assigned an arbitrarily large number.)

Now that we have the three functions f, g, and h, let us define three more functions, $\hat{f}$ (pronounced "f-hat"), $\hat{g}$, and $\hat{h}$, that, for a given situation, are estimates of the theoretical (and often unknown) minimal functions f, g, and h. In other words, $\hat{f}(n)$ is the estimated cost of the minimal path from S through n to G; $\hat{g}(n)$ is the estimated cost of the minimal path from S to n (remember that when we have a path from S to n, it may not be the *minimal* path); and $\hat{h}(n)$ is the estimated cost of the minimal path from n to the closest goal node (which, at the time, is unknown).

Simply stated without proof, the condition necessary for an algorithm producing $\hat{h}(n)$ to be admissible is that the ordering algorithm must produce a numeric value that is guaranteed, for every node n, to be less than or equal to the cost of the minimal path from n to the closest G. In symbols, this condition is the following:

$$\hat{f}(n) \leq f(n)$$

If this condition is always true, then the ordering algorithm is admissible. (Readers interested in the proof can consult *Problem Solving Methods in Artificial Intelligence*, by Nils J Nilsson, 1971, pages 59 to 65.)

Let us consider two cases of algorithms that are known to be admissible. The first algorithm is that for a breadth-first search, which offers no information about the relative value of any node—that is, $\hat{h}(n) = 0$. (Note: the computer program in Part 1 used a different value for the $\hat{h}(n)$ variable D1 for demonstration purposes; however, D1 = 0 will give the same result.) Since zero is a lower bound on the minimal cost of any node, goal or nongoal (ie: $0 \leq h(n)$), the breadth-first algorithm is confirmed to be ad-

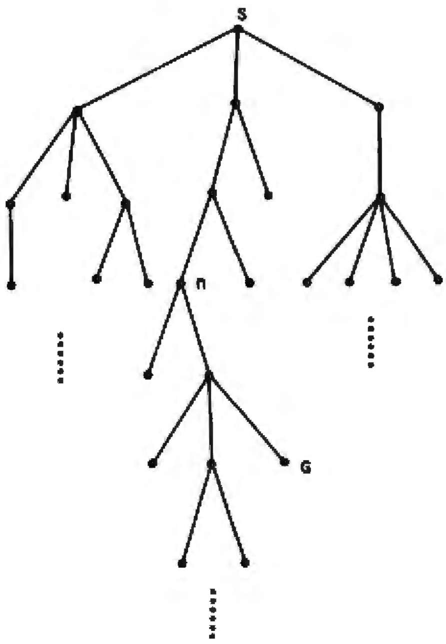


Figure 1: *A partially drawn tree. In this representation, each state (or node) of the problem is represented by a point, and each line represents a legal change from one state to the next. Node S is the original problem, with node n and other nodes representing intermediate steps on the way to solution (node G, the goal node).*

missible by the above inequality. But, as we know from experience, the breadth-first algorithm is nonselective; that is, it expands all nodes in order of increasing depth until it reaches its first (and therefore minimal) goal node. So we can see that its total absence of heuristic information goes hand in hand with, and is a measure of, its extreme inefficiency.

On the other hand, let us assume an ordering algorithm $\hat{h}$ that returns the *exact* cost of the shortest path from n to G; in other words, $\hat{h}(n) = h(n)$ for all n, which still satisfies the above inequality. What does this mean? A moment's reflection will confirm that, first, since this algorithm represents perfect information about the state of the system, it is guaranteed to reach the nearest goal node G; and, second, that it will do so without expanding one unnecessary node. What could be simpler? Since the search algorithm always expands the node with the smallest $\hat{h}$ value, and since in this case the $\hat{h}$ value is the *exact* cost from that node to the goal node, the search algorithm will inexorably come, with each expansion, one node closer to the goal node. So in this case, the presence of total heuristic information is equivalent to maximum efficiency.

From viewing the above two extremes representing

$$\hat{h}(n) = 0$$

and

$$\hat{h}(n) = h(n)$$

we would expect to find an $\hat{h}(n)$ satisfying

$$0 < \hat{h}(n) < h(n)$$

to be between these two extremes of efficiency, with efficiency increasing as $\hat{h}(n)$, for all nodes n, approaches $h(n)$. This is actually the case: given two admissible ordering algorithms A (generating $\hat{h}(n)$) and A* (generating $\hat{h}^*(n)$), A* is said to be *more informed* if $\hat{h}^*$ is always greater than or equal to $\hat{h}$, or:

$$\hat{h}(n) \le \hat{h}^*(n) \le h(n)$$

It has also been shown that A* is then

Listing 1: *The "out-of-place" algorithm. Listing 1a gives the algorithm as implemented in BASIC, to be inserted in the SEARCH program in Part 1; listing 1b shows the structured pseudocode for the algorithm. In this and subsequent listings, the string value of each piece is replaced by its corresponding numeric value (ie: piece "1" has value 1), with "A" through "F" being replaced by the values 10 through 15, respectively.*

(1a)

```
9881  REM -------------LISTING 1-------------
9884  REM
9885  REM "OUT-OF-PLACE" ALGORITHM,
      -ADMISSIBLE
9887  REM
9895  REM ----------------------------------
9900  R1=0
9910  FOR I=1 TO R9; FOR J=1 TO R9
9915  Q=ASC (E$(I,J))
9920  IF Q=46 THEN 9960
9925  IF Q>64 THEN N=Q-55: GOTO 9935
9930  IF Q< =57 THEN N=Q-48
9935  P1=R9*(I-1)+J
9940  REM —P1 IS VALUE OF CORRECT
      TILE IN POSITION I,J
9945  IF N < > P1 THEN R1=R1+1
9960  NEXT J: NEXT I
9965  RETURN
```

(1b)

```
9900   value of puzzle (R1)=0
9910   for each row I
           for each column J
9915       :    Q=ASCII value of row I, column J of puzzle E$
9920       :    if piece not "." (Q≠46)
           :    :    convert piece Q to "true" value N
9935       :    :    P1=value of piece in row I, column J in goal node
9945       :    :    if current piece ≠ value of same position in goal node
           :    :    :    new value of puzzle=old value of puzzle +1
           :    :    :    endif
           :    :    endif
9960       :    end of for-loop J
           end of for-loop I
9965   return
```

guaranteed to expand an equal or smaller number of nodes than A (again, see Nilsson, mentioned above).

One more point has to do with a difference between tree and graph searches. The cost of a node about to be expanded, $\hat{g}(n)$, is equal to its theoretical minimal cost $g(n)$ in a tree because, by definition, there is only one path from the root node S to any other node. Since a graph may contain more than one path from S to n, the cost of a path found may not be the minimal one and so must be labeled $\hat{g}(n)$. However, an admissible algorithm that does not change its nature during the graph search will produce only optimal paths to expanded nodes, so that $\hat{g}(n) = g(n)$; the formal name for the condition that guarantees this result is the *consistency assumption*. All admissible algorithms used in this article satisfy this assumption.

Some Examples

The exhaustive searches examined in Part 1 of this article (breadth-first, depth-first, and limited depth-first algorithms) are all admissible and exhibit one extreme in the information

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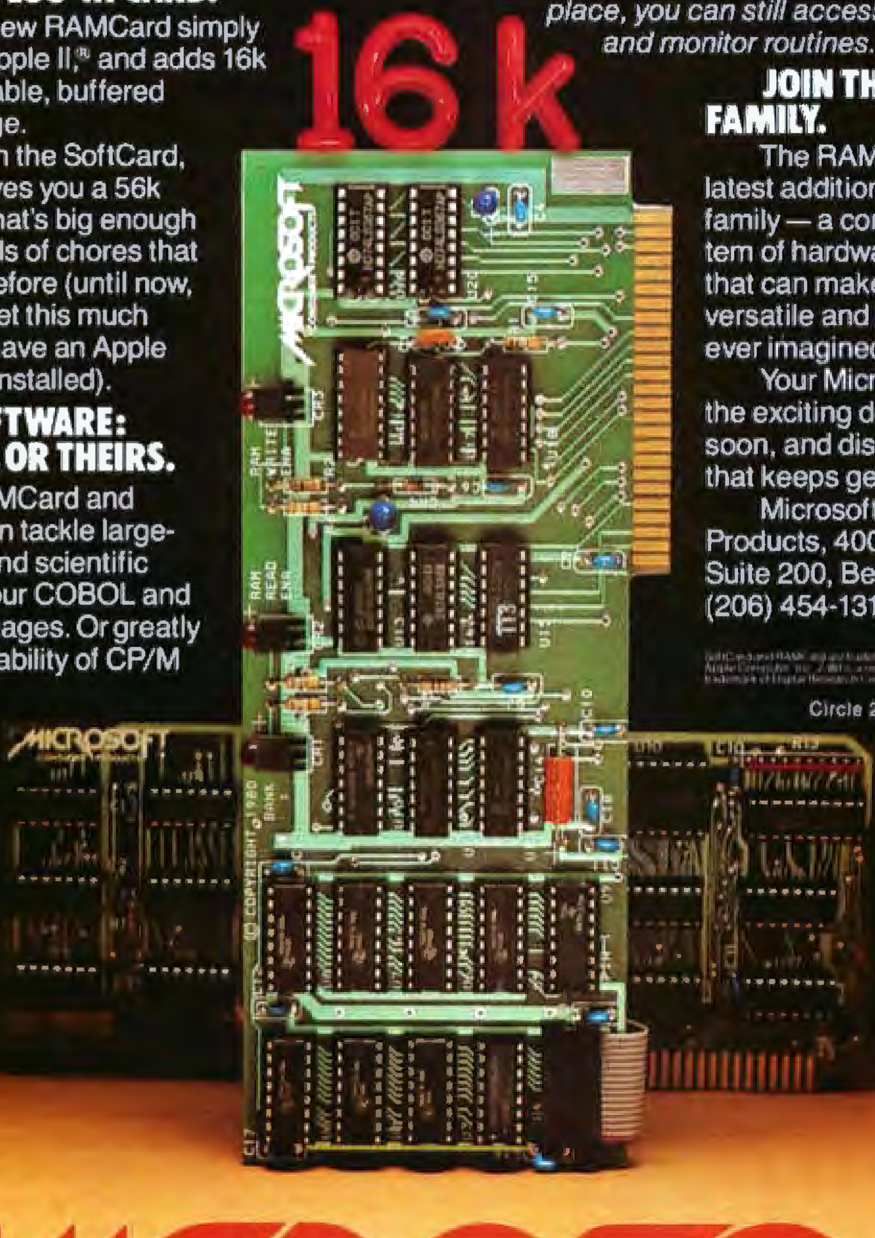
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spectrum: they contribute no heuristic information to the solution of the problem, so $\hat{h}(n) = 0$. The other extreme, that of perfect information (or $\hat{h}(n) = h(n)$), is certainly interesting in theory, but impossible to implement in most cases. We will examine two admissible algorithms that fall between these two extremes.

Remember that we are seeking to define a function $\hat{f}(n)$ that is a lower bound on the minimal number of moves from node n to a goal node G. One plausible algorithm (see listing 1) is the following: $\hat{f}(n)$ equals the number of squares that are not in the same position they are in the goal node G. (In the 8- and 15-puzzles used for illustration, there is only one goal node G.) The informed reasoning used to prove that this is a lower bound on the actual cost to the goal node is the following: if a square (not including the "space" square) is out of place, it will take at least one move, if not more, to put it in place; thus, the $\hat{h}(n)$ generated by this "out-of-place" algorithm will always be less than or equal to the cost of a solution $h(n)$.

Table 1a shows the puzzles used in this article; table 1b shows the results of applying both the breadth-first and the "out-of-place" algorithms to these puzzles. A comparison of the first seven lines of table 1b prompts several useful observations. First, the breadth-first search is considerably more inefficient than the "out-of-place" algorithm; the computer I used, which has 20 K bytes of workspace and will hold 52 nodes before running out of memory, can complete only a four-move puzzle with the first method, but can complete some twelve-move puzzles with the second method before running out of memory. Second, both algorithms show a roughly linear increase in the number

(1a)

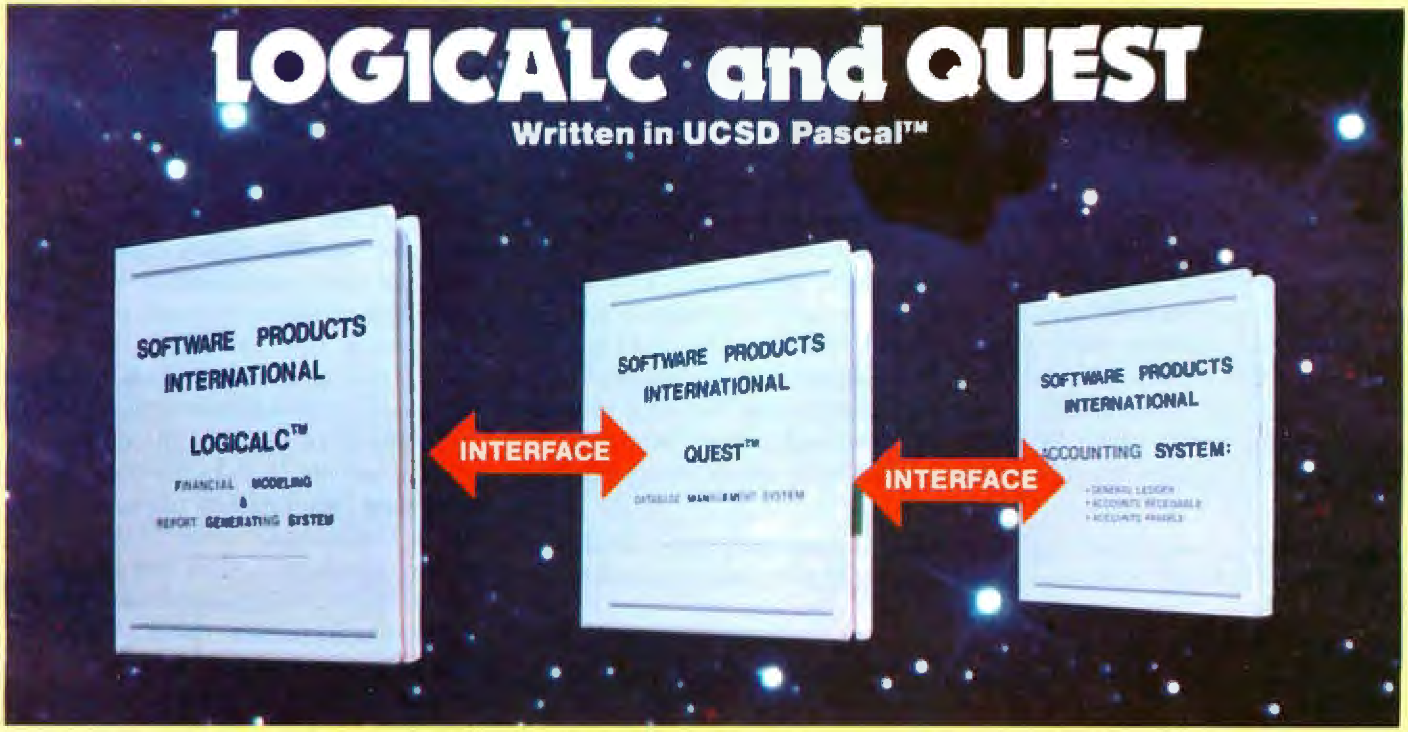
Row	Column 1	Column 3
1	1 2 3 4 5 6 7 . 8	
2	1 2 3 4 . 6 7 5 8	1 2 3 4 5 6 . 7 8
3	1 2 3 . 4 6 7 5 8	1 2 3 . 5 6 4 7 8
4	1 2 3 7 4 6 . 5 8	1 2 3 5 . 6 4 7 8
5	1 2 3 7 4 6 5 . 8	1 2 3 5 7 6 4 . 8
6	1 2 3 7 4 6 5 8 .	1 2 3 5 7 6 4 8 .
7	1 2 3 7 4 . 5 8 6	1 2 3 5 7 . 4 8 6
8	1 2 3 7 . 4 5 8 6	1 2 3 5 . 7 4 8 6
10	. 1 3 7 2 4 5 8 6	1 3 . 5 2 7 4 8 6
12	7 1 3 2 . 4 5 8 6	1 3 7 5 . 2 4 8 6
14	7 1 3 2 8 4 5 6 .	1 3 7 5 8 2 . 4 6
16	7 1 . 2 8 3 5 6 4	. 3 7 1 8 2 5 4 6
18	7 8 1 2 . 3 5 6 4	3 8 7 1 . 2 5 4 6

(1b)

	Breadth-First			"Out-of-Place"		
Puzzle	Nodes Open	Nodes Closed	Total	Nodes Open	Nodes Closed	Total
(1,1)	3	1	4	3	1	4
(2,1)	7	4	11	5	2	7
(2,3)	4	3	7	3	2	5
(3,1)	9	8	17	6	3	9
(3,3)	10	9	19	4	3	7
(4,1)	12	11	23	6	4	10
(4,3)	16	21	37	6	4	10
(5,1)	*OM*	(29)	*OM*	9	7	16
(5,3)			*OM*	7	6	13
(6,1)			*OM*	12	9	21
(6,3)			*OM*	13	13	26
(7,1)			*OM*	13	10	23
(7,3)			*OM*	17	17	34
(8,1)			*OM*	14	11	25
(8,3)			*OM*	25	26	51
(10,1)			*OM*	14	13	27
(10,3)			*OM*			*OM*
(12,1)			*OM*	20	20	40
(12,3)			*OM*			*OM*

Table 1: *Comparison of breadth-first and "out-of-place" algorithms on selected problems. The puzzles in table 1a can be identified by a pair of numbers giving the row and column in which the puzzle is found. The row number gives the number of moves to solution; puzzles in the same column are subsets of the same problem. (These match puzzles listed in Part 1 of this article.) Table 1b gives a comparison of breadth-first versus "out-of-place" algorithms for selected problems. The relationship between nodes open and nodes closed is: total = nodes open + nodes closed. (*OM* indicates that the computer's limit of about 50 nodes was exceeded. The parentheses around the 29 in line (5,1) denote that the breadth-first search ran out of room after expanding 29 nodes.) The "out-of-place" algorithm's ability to solve more complex problems using the same amount of memory indicates greater power when compared to the breadth-first search.*

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of nodes expanded within a certain range (levels 1-3 and 1-4, respectively), with the ratio of nodes expanded to the theoretically minimum number of nodes to be expanded being roughly 3:1 and 1:1, respectively. Third, this ratio progressively increases outside each algorithm's range of linearity; this implies that the maximum efficiency available from each algorithm decreases with the complexity of the puzzle—in other words, as the puzzle becomes more involved, the $\hat{h}$ that is calculated drifts more and more from the theoretical h toward zero (ie: no information), and the algorithm breaks down (ie: approaches an exhaustive search).

A final observation is that the $(n,1)$ puzzles seem easier to solve than the $(n,3)$ puzzles. (Puzzles with the same last subscript are extensions of each other.) This trend is more obvious on comparison of the numbers in the "nodes closed" column in table 1b (which is a measure of the difficulty of the problem in that it is related to the number of nodes expanded in the attempt to find a solution). Note also that the nonlinear rise of the "nodes closed" column is greater for the $(n,3)$ puzzles than for the $(n,1)$ puzzles. This suggests that the behavior of an algorithm outside the range of linearity described above cannot be expressed by a simple nonlinear function, but only through a range of values that is highly sensitive to the individual puzzle under consideration.

Listing 2: *The minimum-distance algorithm. Listing 2a gives the algorithm in BASIC, to be inserted in the SEARCH program of Part 1; listing 2b is the structured pseudocode.*

(2a)

```
9885  REM --------------LISTING 2--------------
9887  REM
9890  REM MINIMUM-DISTANCE
      ALGORITHM; ADMISSIBLE
9893  REM
9910  REM ------------------------------------------
9900  R1=0
9910  FOR I=1 TO R9: FOR J=1 TO R9
9915  Q=ASC (E$(I,J))
9920  IF Q=46 THEN 9960
9925  IF Q>64 THEN N=Q-55: GOTO 9935
9930  IF Q<=57 THEN N=Q-48
9935  I1=INT ((N-1)/R9)+1
9940  REM —GIVEN SQUARE N,
      1<=N<=15, FIND
9941  REM (I1,J1)=POSITION OF N IN
      SOLVED PUZZLE
9945  J1=N-R9*(I1-1)
9950  REM —H-HAT IS SUM OF DISTANCES
      EACH SQUARE
9951  REM   IS FROM GOAL POSITION; "."
      SQUARE NOT COUNTED
9955  R1=R1+ABS(I-I1)+ABS (J-J1)
9960  NEXT J: NEXT I
9965  RETURN
```

(2b)

```
9900    value of puzzle (R1)=0
9910    for each row I
             for each column J
9915         :     Q=ASCII value of row I, column J of puzzle E$
9922         :     if piece not "." (Q≠46)
             :     :     convert piece Q to "true" value N
9935         :     :     I1=row # of piece in goal node
9945         :     :     J1=column # of piece in goal node
9955         :     :     new value of puzzle = old value of puzzle +
                               (difference of row values) + (difference
                               of column values)
             :     :     endif
9960         :     end of for-loop J
             end of for-loop I
9965    return
```

Minimum-Distance Algorithm

The *minimum-distance algorithm* described here is the most efficient I have worked with—one that I have not been able to improve even when dropping the admissibility constraint. The algorithm (see listing 2) may be described as follows: for each piece in the puzzle (not including the "." piece), the value of the algorithm is increased by the number of rows plus the number of columns the piece is away from its final position in the goal state (ignoring any pieces in the way). For example, if the "1" piece is in row 2, column 3, then that piece is $(2-1)+(3-1)=3$ squares away from its final goal position (row 1, column 1) and so adds 3 to the $\hat{f}$ value of that puzzle. Table 2 shows the value of puzzle (6,1) using this algorithm.

Because the figure given to each piece is a conservative estimate of how many moves it will take to get that piece into place (it will be more if the other pieces get in the way), the $\hat{f}$ calculated as the sum of these values must be a lower bound on the true cost f associated with a given puzzle; therefore, this minimum-distance algorithm is admissible.

Table 3 shows the result of using this algorithm on the puzzles in Table 1a, with comparison values given for the "out-of-place" algorithm. The results are far more pleasing than those of any algorithm that we have looked at—in fact, you might say this is the first algorithm of any practical use. The algorithm, like the "out-of-place" algorithm, is "perfect" through order 4 (although a counterexample may exist), but notice that the nonlinear increase in the "nodes closed" column is more gradual and more nearly straight-lined for the minimum-distance algorithm than it is for the "out-of-place" algorithm. Although the minimum-distance algorithm does drift from the theoretical h value toward zero as the problem complexity increases, it does so less severely than the "out-of-place" algo-

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rithm; this is because the minimum-distance algorithm is more informed than the other algorithm. Its better information is expressed in the generation of fewer erroneous nodes during the solution of a puzzle.

One aspect of table 3 is, however, misleading: the order-12, -14, and -16 puzzles show identical "nodes closed" values for two sets of puzzles that were earlier said to be unequal in complexity, which might suggest that the algorithm somehow minimizes the scatter effect caused by the different complexities of puzzles of the same order postulated earlier. This, however, is not the case: solution by the minimum-distance algorithm of a number of randomly selected order-12 puzzles reassured me that no such minimizing effect was taking place; the values in "nodes closed" for these puzzles were 12, 13, 14, 14, 18, 20, and >20 (this last value was the result of the computer running out of memory).

Although the minimum-distance algorithm is usually reliable, there is at least one type of problem that renders it virtually useless. An example of one such puzzle is given in figure 2, and an analysis of the algorithm's inability to solve it gives us a clue toward the construction of a more powerful admissible algorithm. Although the algorithm gives this puzzle a value of four, I have not been able to find a solution (by hand) of under sixteen moves, and the first fifty nodes of the tree, generated by this algorithm before my computer ran out of memory, show no appreciable gain toward the goal node. In fact, after generating nodes 37 through 40, at level 10 (see figure 2), the algorithm abandons them to expand nodes of levels 2 through 4, clearly indicating that the algorithm has found the nodes on levels 6 through 10 to be unpromising. Although I have failed to find an admissible algorithm that performs better with this puzzle, I am sure that such an algorithm will have to take into account the extra number of moves that pairs of pieces in each other's "home" positions (here, the "5" and "6" and the "7" and "8") generate.

Nonadmissible Algorithms: Theory

Comparatively little is known about the performance of nonadmissible algorithms—that is, algorithms whose returned value $\hat{h}$ is not necessarily a lower bound on the true cost of a solution h. This is because no common feature (in terms of the algorithm's goal-finding performance)

(a) Puzzle	(b) Goal Node	(c) Breakdown of Moves	
1 2 3	1 2 3	pieces 1,2,3,6,8 in place	= 0
7 4 6	4 5 6	piece 4 is 0 rows, 1 column off	= 1
5 8 .	7 8 .	piece 5 is 1 row, 1 column off	= 2
		piece 7 is 1 row, 0 columns off	= 1
		f value of puzzle	= 4

Table 2: *Evaluation of puzzle (6,1) by the minimum-distance algorithm. This algorithm sums the distance each piece is from its final position (the goal node) to arrive at an estimate of the number of moves to solution. Column (a) is the problem posed in puzzle (6,1); column (b) is the goal node; column (c) gives each piece's contribution to the total number of moves to solve the puzzle (the "." piece, which represents the blank, is not included in the evaluation).*

Puzzle	"Out-of-Place" Nodes Closed	"Out-of-Place" Total	Minimum Distance Nodes Closed	Minimum Distance Total
(1,1)	1	4	1	4
(2,1)	2	7	2	7
(2,3)	2	5	2	5
(3,1)	3	9	3	9
(3,3)	3	7	3	7
(4,1)	4	10	4	10
(4,3)	4	10	4	10
(5,1)	7	16	6	13
(5,3)	6	13	5	12
(6,1)	9	21	7	15
(6,3)	13	26	7	15
(7,1)	10	23	7	15
(7,3)	17	34	7	15
(8,1)	11	25	8	18
(8,3)	26	51	10	21
(10,1)	13	27	10	21
(10,3)		*OM*	12	24
(12,1)	20	40	14	29
(12,3)		*OM*	14	29
(14,1)		*OM*	16	32
(14,3)		*OM*	16	32
(16,1)		*OM*	18	35
(16,3)		*OM*	18	35
(18,1)		*OM*	20	40
(18,3)		*OM*		*OM*

Table 3: *Comparison of the "out-of-place" algorithm with the minimum-distance algorithm for selected problems.*

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that applies to nonadmissible algorithms as a class has been found: a given nonadmissible algorithm, compared to a good admissible one, may perform anywhere in the range of consistently better to consistently worse. In fact, it is possible to devise a nonadmissible algorithm that is worse than a "no-information" breadth-first search.

In any case, two characteristics of a nonadmissible algorithm follow from its failure to meet the conditions of admissibility. One is that it is not guaranteed to find a goal node; the other is that a goal node found by a nonadmissible algorithm may not be an *optimal* goal node (ie: there may exist another, shorter, path to the same node). These are serious but not insurmountable defects when considered in conjunction with a real-work problem because, in the first place, a given algorithm will not be used unless it has a history of solving similar problems. (Nonadmissible algorithms are devised by a process of trial and error, and the only measure of a given algorithm's effectiveness is its ability to produce solutions to problems of a similar complexity whose solutions are already known.) In the second place, the production of an optimal node may not be as important as the production of some goal node, optimal or otherwise.

(Other methods may be used in conjunction with or in place of nonadmissible algorithms to produce a goal node. All these methods sacrifice the guarantee of finding a goal node by economizing on the number of intermediate nodes saved. Successors can be pruned from memory either when they are generated or when memory is filled; or, in a completely different approach, a depth-first search of a given maximum depth sweeps across the tree, storing only the best node encountered thus far.)

Listing 3: *Modification needed to derive the algorithm NA-I (nonadmissible algorithm 1). This modification to the BASIC code in listing 2 delivers misinformation to the SEARCH program, rendering it incapable of solving even the simplest puzzles.*

```
9890 REM --------------LISTING 3--------------
9891 REM
9894 REM ALGORITHM NA-I;
     NONADMISSIBLE
9896 REM INSTRUCTIONS: ADD THIS
     CODE TO LISTING 2
9897 REM (THE MINIMUM-DISTANCE
     ALGORITHM)
9898 REM
9899 REM ------------------------------------------
9961 REM
9962 L1=100-R1
|
|
```

Listing 4: *Modification needed to derive the algorithm NA-II (nonadmissible algorithm 2). This modification to the BASIC code in listing 2 consistently performs as well as, or better than, the minimum-distance algorithm. Since the algorithm is nonadmissible, the performance is not guaranteed.*

```
9890 REM --------------LISTING 4--------------
9891 REM
9892 REM ALGORITHM NA-II;
     NONADMISSIBLE
9895 REM
9896 REM INSTRUCTIONS: ADD THIS
     CODE TO LISTING 2
9898 REM
9899 REM ------------------------------------------
9954 REM
9955 I9=ABS (I-I1):J9=ABS
     (J-J1):R1=R1+I9+J9
9957 IF I9>0 AND J9>0 THEN R1=R1+1
```

Some Examples

An example of a *bad* nonadmissible algorithm is easy to generate: simply subtract the value calculated by the minimum-distance algorithm (which is a good algorithm) from an arbitrarily large number. This results in an algorithm that assigns a high number to a node close to a goal node (making it one of the last to be expanded) and a lower number to a node that is further away from a goal node; see algorithm NA-I, given in listing 3. The algorithm, when run with a problem of order 2 or greater, will fill up almost any computer's memory without producing a solution because this algorithm will expand a "good" node only after it has expanded every worse node in the problem tree. At fifty nodes (my computer's limit) on problem (2,1), the algorithm was much further away from a solution than when it started.

On the other hand, an example of a *good* nonadmissible algorithm—in this case, one that performs better than the minimum-distance algorithm—is much harder to find. In fact, a considerable amount of work in several directions yielded only one positive result. The algorithm, labeled NA-II (see listing 4), is an attempt to correct the minimum-dis-

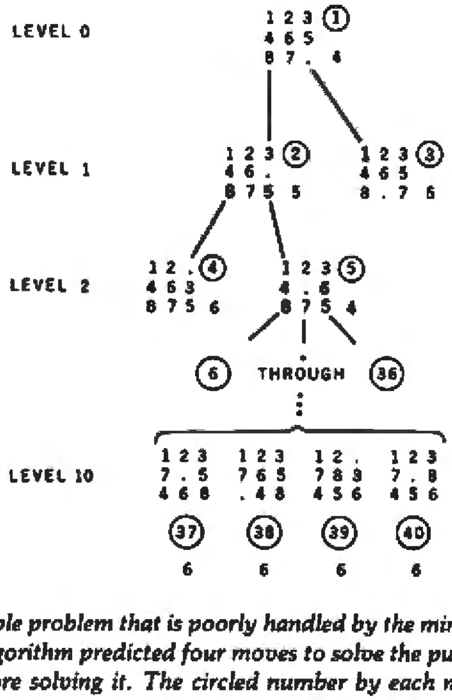
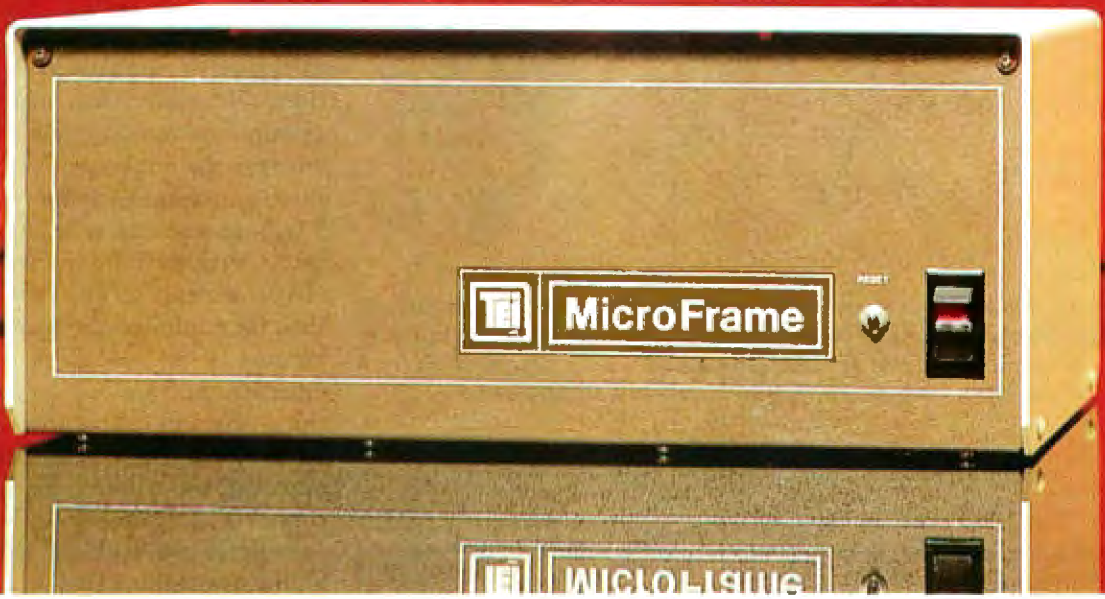


Figure 2: *A sample problem that is poorly handled by the minimum-distance algorithm. Although the algorithm predicted four moves to solve the puzzle, the computer ran out of memory before solving it. The circled number by each node indicates the order in which the nodes were generated; the numbers not circled are the f values predicted by the algorithm.*

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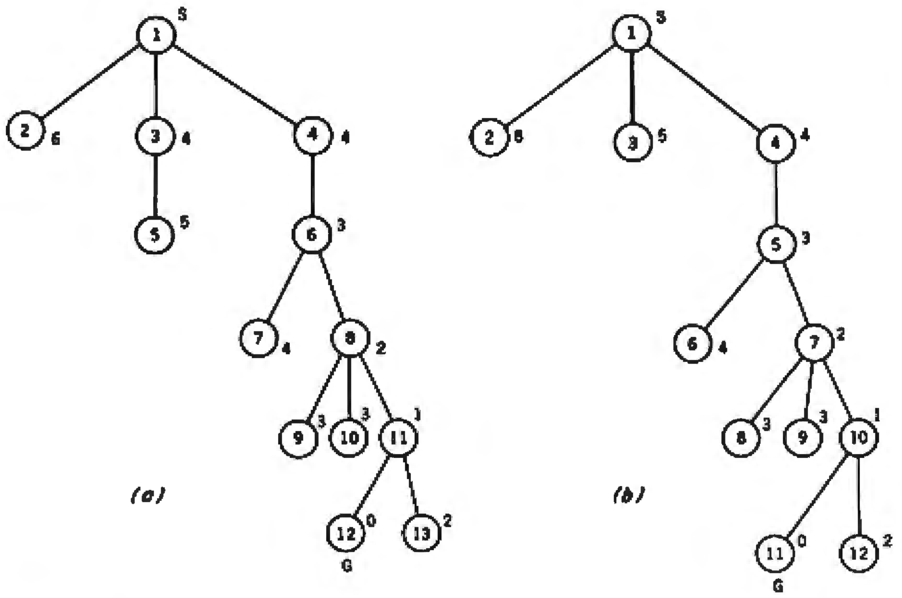


Figure 3: *Expansion of puzzle (5,1) by the minimum-distance algorithm (figure 3a) and NA-II (figure 3b). The numbers inside each node denote the order in which they were generated; the numbers not circled are the estimated f values generated by each algorithm. In this case, the nonadmissible algorithm performs slightly better.*

tance algorithm for harder problems by adding 1 to the original value for each node that is at least one row *and* one column away from its position in the goal node. Only two puzzles out of the entire set did better than the minimum-distance algorithm (see table 2), but the rest matched it, making NA-II a slightly better algorithm.

Figures 3a and 3b show the expansion of problem (5,1) by the minimum-distance and NA-II algorithms, respectively, as well as the order in which they were expanded and the calculated $\hat{h}$ estimate by each algorithm. Note that NA-II made the right decision in not expanding node 3, whereas the minimum distance algorithm underestimated the cost of node 3 (whose true cost is 5) and unnecessarily evaluated it. So we see that NA-II, at least in this case, is better than the minimum-distance algorithm because it is less likely to underestimate the value of a node (something that an admissible algorithm tends to do). As an extension of that, however, we confirm that this algorithm is nonadmissible because it sometimes overestimates the value of a node (something that an admissible algorithm cannot do). An example of an overestimated node is node 2 in figure 3b; its true value is 6, but it was estimated at 8 by algorithm NA-II.

Observations and Questions

• The word "cost," up to this point, has only been used to refer to the numeric value associated with the shortest path from the node to the closest goal node. But it has two new and significant meanings when referring to the cost of a solution. One index of the cost of a solution is the number of nodes closed (ie: expanded) by the algorithm—this is the measure we have looked at when comparing the efficiency of two algorithms. But another factor must be considered when either speed or money (as expressed in computer time) is a factor. That factor is the complexity of the evaluating algorithm giving $\hat{h}$. A more-informed algorithm may generate fewer nodes but may take considerably more computer time to do it. If speed or money

Glossary

Closed node: *a node whose successors have already been calculated.*
Cost (or value): *a numeric value associated with the shortest path from the start node S to the current node n; the cost of the first goal node found will have some meaning within the problem being solved.*
Depth: *the number of nodes a given node is away from the start node S.*
Expand: *to calculate all legal successors of the current node.*
Goal node: *any node satisfying the set of conditions defined as the desired final state of the problem.*
Node: *an element of a tree used to represent a given state of the problem.*
Open node: *a node that has not yet been chosen for expansion.*
Ordering algorithm: *a formula or procedure generating an ordering value that represents the node's relative likelihood of being chosen for expansion; the node with the lowest ordering value will be expanded next.*
Problem tree (or tree): *a graphic representation of the problem space (or state space) using dots to represent states, and lines connecting dots to represent the transition from one state to the next; all nodes must be generated from one start node S that represents the beginning state of the problem.*
State: *a specific set of values for the variables that define the problem.*
State-space representation: *a breakdown of the problem into the following components: the state variables that can describe the problem in any of its possible configurations; the operators that generate the next set of values (or states) for the problem given the current set (or state); a beginning state S; and a description (not necessarily exact) of the goal node to be found.*
Successors: *those nodes representing all valid "next states" for a given node (or state) as defined by the operators of the state-space representation; the node generating the successor nodes is called the parent node.*

becomes a critical factor before the amount of available memory does, it is possible that the user will decide to use the less-informed algorithm.

• (Question 1) How does a heuristic algorithm assist the tree-searching process? (See the textbox "Answers," which appears on page 212.)

• (Question 2) In the description of the minimum-distance algorithm, the "space" square was not included in the summing of "distances from home place." If this were done, would the algorithm be more powerful? Less? Would it still be admissible?

• Is the tree in figure 4 possible if the algorithm is admissible? Yes, but only if the algorithm is mistaken about the estimated value of one of the open nodes (4, 5, 7, and 8). For example, if the optimal goal node *is* three nodes away from node 4, then the successors of node 8 (or, at the latest, *their* successors) must all come up with $\hat{h}$ values greater than three so that node 4 will be expanded next. An admissible algorithm will always reach the closest goal node first.

• Is this tree possible if the algorithm is nonadmissible? Yes, a nonadmissible algorithm puts no restrictions on the validity of this tree.

• (Question 3) Remember the meaning of $\hat{f}$, $\hat{g}$, and $\hat{h}$: $\hat{f}(n)$ is the estimated distance from start node S through node n to the closest goal node; $\hat{g}(n)$ and $\hat{h}(n)$ are the estimated distances from S to n and from n to the same goal node, respectively. Isn't the tree in figure 4 a good argument for using $\hat{f}$ instead of $\hat{h}$ to order the expansion of nodes?

• (Question 4) The minimum-distance algorithm has been the best algorithm we have seen for the 8- and 15-puzzle. Try adding the line

```
9963  R1=R1 * F9
```

to the $\hat{h}$-calculating subroutine at 9900. This will increase the $\hat{h}$ value to nodes that were formerly underestimated by the admissible algorithm. The algorithm will now be nonadmissible, but will it also be more "piercing"? Try F9=1.01, 1.1, 1.5 (and other values), and test the new algorithm on puzzles of eight moves or more.

• (Question 5) Why is the nonadmissible algorithm NA-I a worse algorithm than the breadth-first search? Isn't an exhaustive search, which uses no heuristic information, the most inefficient search possible?

• As mentioned before, certain modifications to the method of searching may be desirable over the use of a nonadmissible algorithm. In certain situations, the judicious application of one of these methods may be more productive in finding a goal node than the "pure" methods described in this article.

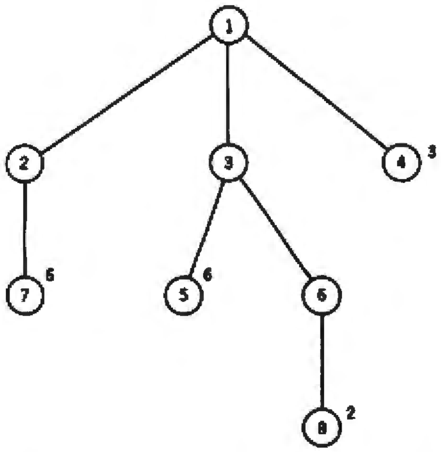


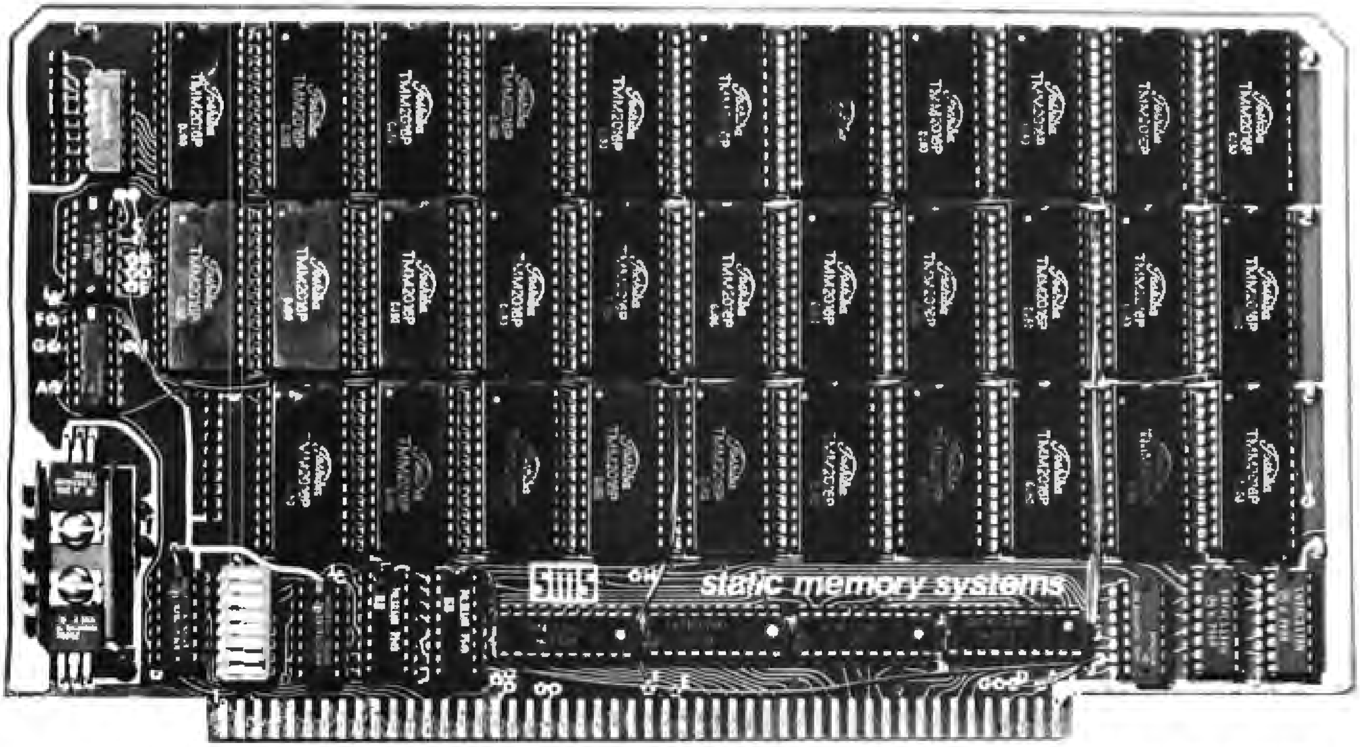
Figure 4: *A hypothetical partially expanded tree, used for visualizing questions posed in the text.*

Conclusions

This article has dealt with the searching of state-space trees and graphs. Other kinds of trees (AND/OR trees and game trees, to name two) are used in theorem proving and game playing, and a number of other questions can be raised.

For example, how can we evaluate nonadmissible algorithms? What modifications should we make when we have a limited amount of memory? While I have discovered that x amount of artificial intelligence in a program requires at least "x cubed" amount of work, if not more, I hope that this article will prompt more people to look into (and write about) this interesting branch of artificial intelligence. ■

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Answers

1. A heuristic algorithm assists the tree-searching process using information in the current state (that is, in the current node, without looking at its relationship to any other node but the goal node) to assess the relative likelihood of that node leading to a solution. More likely nodes receive a lower value than less likely nodes, so the controlling program, in choosing to expand next the node with the lowest ordering value, is choosing the node most likely to lead to the shortest solution.

2. This variation of the minimum-distance algorithm is slightly less powerful, primarily because it is no longer admissible. The puzzle

```
1 2 3
4 5 6
7 . 8
```

is a simple counterexample. Since both the "." piece and the "8" piece are one square away from their positions in the goal state, this algorithm would return the value 2. However, since the true solution value is 1, this one counterexample is enough to show that the algorithm is nonadmissible.

3. If the algorithm used is admissible, the use of $\hat{h}$ guarantees finding the closest goal node—this is mathematically unarguable. But if the algorithm is nonadmissible and, at the same time, relatively accurate, the use of

$$f(n) = g(n) + \hat{h}(n)$$

may be a good idea indeed. If the estimate $\hat{h}$ costs in figure 4 are accurate relative to each other, then

$$f(\text{node } 4) = 1 + \hat{h}(\text{node } 4) = 1 + 3 = 4$$
$$f(\text{node } 8) = 3 + \hat{h}(\text{node } 8) = 3 + 2 = 5$$

may rightly cause node 4 to be expanded first.

4. The results for this new algorithm will be identical to those of the minimum-distance algorithm, even though the new algorithm may be nonadmissible. Multiplying the results by a constant will change the values of the nodes but not the ordering of the nodes to each other. *On the other hand, adding*

9963 if R1>F8 THEN R1=R1+F9

or

9963 IF R1<F8 THEN R1=R1+F9

will change the relationship of the nodes to each other. Experiment with these for various values of F8 and F9; a suggested starting value for F8 is 4.

5. No. Misinformation is worse than no information at all, and that is what NA-1 is giving. In assigning high values to nodes that should be low, and vice versa, this algorithm is forcing the driving program to always expand the least promising node first.

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Name________

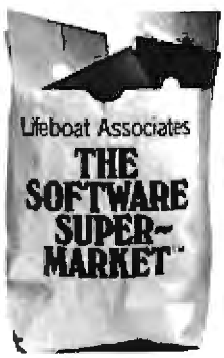
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As an example of what T/Maker II can do, see the chart below. The operator entered only the data shown in boldface. T/Maker II calculated and reported all the other values.

	— Actual —			Growth		Total	—Projected—		
	1978	1979	1980	Rate	Average	(000's)	1981	1982 *	1985
Item A	**42,323**	**51,891**	**65,123**	24.04	53,112	159.34	80,782	100,206	191,262
Item B	**45,671**	**46,128**	**49,088**	3.67	46,962	140.89	50,891	52,761	58,791
Total	87,994	98,019	114,211	13.93	100,075	300.22	131,673	152,966	250,053
% Item	48.10	52.94	57.02	8.88	52.69	158.1	61.35	65.51	76.49
% Item	51.90	47.06	42.98	-9.00	47.31	141.9	38.65	34.49	23.51
Total	100.00	100.00	100.00	—	100.00	300.0	100.00	100.00	100.00

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Drawing with UCSD Pascal and the Hiplot Plotter

Dr James Stork
Humbolt State University
Humbolt Bay Project
Arcata CA 95521

In the course of my work for the University of California Sea Grant program, I have needed to plot oceanographic data on a Houston Instrument Hiplot plotter. Because my operating system is exclusively UCSD Pascal, I have developed routines using that system. I have been completely satisfied with this system and would recommend it to anyone who intends to develop serious microcomputer software beyond the level of simple computer games.

The plotter software shown in the listings demonstrates at least two facilities of the UCSD Pascal system that I have found very useful. These are the ability to easily link an external machine-language subroutine to any Pascal program, and to store a library of often-used units and procedures in the system's library.

The "plotter" Unit

The main unit, called "plotter", is given in listing 1. Those of you who are familiar with the Pascal language will notice that the normal program heading is absent, and in its place is the declaration "unit plotter;" rather than "program plotter;". This is to inform the compiler that the procedures contained in this unit are meant to be linked to another "using" program and are not run alone.

Once a unit is written, compiled, and stored in the system library, it can be used by any Pascal program through the "uses" statement.

The interface section in listing 1 tells the linker that the following declarations (one type and six procedures) may be used by the program that is linked to the unit. The implementation section variables and procedures are to be used solely in the implementation of the unit and are not to be available to the program using the unit. For example, the procedure "plotstep" cannot be used by the program using the unit (since it is not named in the interface section of the unit), while the procedure "plotline" can be used.

Once a unit is written, compiled, and stored in the system library, it can be used by any Pascal program by including the statement "uses xxxxx;" after the program heading of the using program (assuming the unit is named "xxxxx" in the library; see the example in listing 2). When the main program is compiled and run, the linker will link the unit into the using program and will link the procedure "plotstep" (which is external to "plotter") into the "plotter" unit.

It is important to note here that "plotstep" is not linked to the "plotter" unit before it is stored in the system library. Both the unit and the external procedure "plotstep" are stored in the system library in their compiled and assembled versions, respectively. The linking of one to the other is done when the linker links them into the using program. (This little piece of knowledge is not mentioned anywhere in the UCSD Pascal manual, and it caused me a considerable amount of grief until I called Softech to get myself back on the right path. The people at Softech have given me a great amount of help above and beyond the call of duty; although their documentation might be less than complete, their helpful attitude with problem calls leaves nothing to be desired.)

About the Author

Jim Stork, a research oceanographer, has been "a confirmed computer freak" since the beginning of the microprocessor industry. Recently he has been using a Z80-based microcomputer to do data acquisition and analysis for a computer modeling study of Humbolt Bay.

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PLOTLINE (penpos:integer;xplot,yplot:real);

This procedure draws a line. Its parameters are:

- penpos: Position of the pen during the plot.
- penpos = 0: Initialize the plotter. This must be done before any plotting can be done. When penpos is 0 the computer assumes that the current pen location is location (0,0)—namely, the lower left corner of the plotting bed. The subroutine will remind you to move the pen to that position before it actually sets these coordinates. When penpos = 0, xplot and yplot can be any values since they will be ignored.
- penpos = 1: Pen up (ie: no line will be drawn).
- penpos = 2: Pen down (ie: line will be drawn).
- xplot: x position (ie: left and right) in inches to which the pen will be moved. This may be any value from 0 to 10 inches.
- yplot: y position (ie: forward and backward) in inches to which the pen will be moved. This may be any value from 0 to 7 inches.

PLOTSYMBOL (sym:integer;height:real);

This procedure is used by procedure plotarray to draw one of five symbols to represent a data point. The symbol is drawn at the current pen position. Its parameters are:

- sym: Symbol definition.
- height: Height of symbol to be drawn.

PLOTWHERE (var px,py:real);

This procedure will place the current pen position coordinates in inches into the variables px and py.

PLOTSTRING(px,py,height,theta:real; line:string);

This procedure plots a string of characters anywhere on the plot. Its parameters are:

- px,py: coordinates in inches of lower left corner of first character to be plotted.
- height: height of characters in inches.
- theta: angle with respect to the x axis at which the characters will be drawn (in degrees).
- line: a string variable containing the characters to be drawn (maximum of 80 characters)

Subscripts and superscripts are supported by the software. In order to accomplish superscripting, enclose the letters to be superscripted in brackets (eg: this is a [superscript]). To create subscripts, use the brackets in reverse order (eg: this is a]subscript[). If an up-arrow is specified, it will be drawn with a length as specified in the height parameter and pointing in the direction given in the theta parameter.
in the direction given in the theta parameter.

PLOTAXIS(px,py,leng,theta,min,max,tic:real;name:string);

This procedure draws an axis with tic marks and optionally labels each mark and writes the name of the axis. Its parameters are:

- px,py: the origin of the axis in inches.
- leng: the length of the axis in inches. If leng is negative, no labeling of tic marks or axis will be done.
- theta: angle of the axis with respect to the x direction in degrees.
- min: value of tic mark at origin.
- max: value of outer end of axis (these two values are used to calculate the labels of the tic marks).
- tic: frequency of tic marks on axis (eg: if tic = 5, tic marks will occur every 5 units on the axis). If tic is negative, the labels will occur on the counterclockwise side of the axis; otherwise, they will be on the clockwise side.
- name: string variable containing the name of the axis.

PLOTARRAY (nopoints,freq,sym:integer;px,py,xmin,xmax,ymin,ymax,height, xlen,ylen:real;var x,y:coord);

This procedure plots an array of x and y coordinates. Its parameters are:

- nopoints: Number of points to be plotted.
- freq: Frequency of identifying symbol (0 = no symbols, 1 = every point, 2 = every other point, etc). If freq is negative, only the points will be plotted with no interconnecting lines.
- sym: Identifier of symbol to be plotted at points:
  - sym = 1:triangle.
  - sym = 2:X.
  - sym = 3:square.
  - sym = 4: + .
  - sym = 5:vertical line.
- px,py: Coordinates of origin of array plot.
- xmin,ymin: Minimum value of variables.
- xmax,ymax: Maximum value of variables.
- height: Height of symbols in inches.
- xlen,ylen Size of area to be plotted.
- x,y: Variables of type coord (no more than 256 points) to be used in the plot; coord is a type that is predefined in the plotter subroutines and may be used in the 'var' section of your program.

Table 1: *Summary of procedures and parameters from the Pascal unit "plotter".*

From this discussion you can see that the unit makes the following procedures available to the using program: plotline, plotsymbol, plotstring, plotwhere, plotarray, and plotaxis. (See table 1 on page 216.) It also makes the definition of the type "coord" available to the using program. In fact, if the procedure "plotarray" is going to be invoked, a variable of the type "coord" *must* be passed as a parameter to it.

The basic plotting algorithm in all of the plotter procedures is expressed in the procedure "plotline".

Basic Plotting Procedures

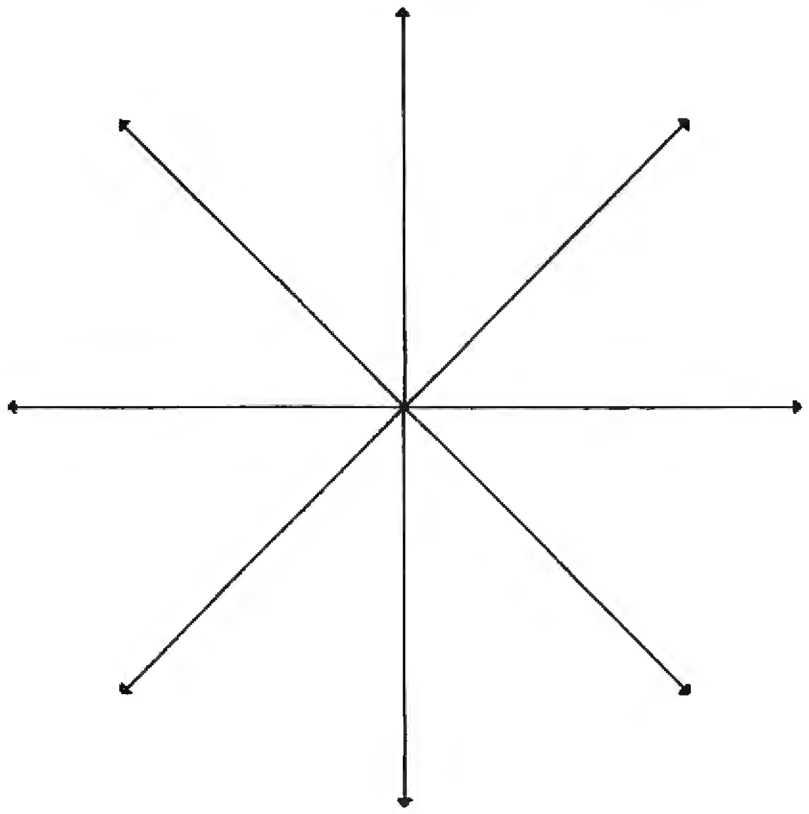
Now that you're familiar with how the unit interfaces to the using program, let's see how the various procedures accomplish their tasks and how the unit is put together. As you might imagine, the construction of the unit after the implementation and interface sections is simply a series of Pascal procedures with no program body. If we did not want to make these procedures into a unit, we could simply incorporate them into a Pascal program as normal procedures.

The Hiplot plotter can move its pen in eight directions. These are left, right, forward, backward, and the four moves at 45° (see figure 1). In addition, we have the pen-up and pen-down movements. With these ten movements, the plotter is capable of grand and wondrous things.

The most fundamental procedure in the program is the machine-language procedure "plotstep" (see listing 3). The purpose of this procedure is simply to take the elementary pen-movement commands passed to it and send them to the plotter port. (The pen-movement commands are the letters p, q, r, s, t, u, v, w, y, and z sent to the plotter through a serial port.)This procedure was written to operate on a Z80-based computer running at 2.5 MHz with the plotter set to 0.005 inches per step. Because of this, the timing loops might have to be adjusted to allow the procedure to operate correctly on a different machine.

The operation of procedure

"plotstep" is straightforward: it simply receives the plot command from the Pascal system (passed on the system stack along with the return address) and checks the status of the plotter (bit 1, port hexadecimal 7D in this case). It then checks to see if the command is a pen-up or pen-down command, or a pen-movement command. In each case, it takes appropriate timing action depending upon the pen movement requested. If the Pascal running on your system includes the logical device "REMOUT:", the plotter could be attached to the port addressed by "REMOUT:" and the plotting commands issued to the plotter through that port.



BASIC PLOTTER DIRECTIONS

Figure 1: *Basic plotter directions available to the Houston Instrument Hiplot. This drawing was made by the Hiplot plotter.*

Once this machine-language subroutine is edited and assembled, it is a simple matter to use the linker to incorporate it into a Pascal program as an external procedure or to store it in the system library for use in the "plotter" unit.

The basic plotting algorithm in all of the plotter procedures is expressed in the procedure "plotline". This algorithm is simply passed a parameter ("penpos") that tells it whether the pen move is to be made with the pen up or down, and the endpoint of the next line to draw. It then calculates the best straight-line fit from the current position of the pen ("xpos" and "ypos") to the point selected ("xplot" and "yplot"). With the pen either up (penpos=1) or down (penpos=2), it draws the line. The algorithm used is simply a translation of the BASIC algorithm supplied by Houston Instrument with the plotter into Pascal.

A special case of "plotline" occurs when penpos=0. In this case, the pen is assumed to be at the lower-left corner of the plotter bed, and the variables "xpos" and "ypos" are initialized to that point. The machine-language subroutine "plotinit" is executed during this initialization. The procedure simply initializes the serial

output port to 9600 bps (bits per second) to make it compatible with the data-input rate of the plotter (see listing 4). "Plotline" with the penpos of 0 *must* be executed before any plotting can be done with the other procedures. In each case of a pen movement, procedure "plotline" checks to make sure that a plot off the bed of the plotter is not being attempted and, if so, reports this to the console rather than attempting the plot.

The procedure "plotstring" uses procedure "plotchar" to draw characters on the plot. Procedure "plotstring" is passed the starting location of the lower-left corner of the first character to be plotted, the height of the characters (which should be a multiple of 0.035 to give the best-formed characters), the angle (in degrees relative to the long axis of the paper) at which the string is to be plotted, and a string of characters to be plotted.

The way in which the characters are plotted is interesting. I decided that I had to develop an interpreter for plotting the various pen moves. Plotting any character, I concluded, would be a combination of straight lines in the fundamental directions available on the plotter.

Rather than simply using "plotline" to do all the moves for each character, the moves to plot each character are generated in a coded form using two vector pads made up of two groups of keys on the keyboard. One vector pad represents moves with the pen up and the other with the pen down. The letters d, w, a, and x are used for moves in the indicated directions with the pen up, and 7, 8, 9, o, l, k, j, and u for moves in the indicated direction with the pen down. The length and direction of each move are determined by the height and orientation of the character to be plotted. As you can see in the listing of "plotchar", each character is coded as a series of moves terminated with the character "i".

In operation, the procedure takes the character passed to it, assigns the string of moves to the string variable PLOT, then decodes that string into a series of pen movements. A few special cases need to be noted at this

Text continued on page 242

Listing 1: *The Pascal unit "plotter". This unit, which can be used by other Pascal programs, contains several routines that simplify the process of drawing lines and characters on the Houston Instrument Hiplot plotter.*

```
unit plotter;

   interface (*These procedures and types are available to using program*)

     type
       coord=array[1..250] of real;
     procedure plotline(penpos:integer;xplot,yplot:real);
     procedure plotsymbol(sym:integer;height:real);
     procedure plotstring(px,py,height,theta:real;line:string);
     procedure plotwhere(var px,py:real);
     procedure plotarray(nopoints,freq,sym:integer;
       px,py,xmin,xmax,ymin,ymax,
       height,xlen,ylen:real;var x,y:coord);
     procedure plotaxis(px,py,leng,theta,min,max,tic:real;
       name:string);

   implementation (*Everything else is local to the unit*)

     const
       pi=3.14159;
       screenwidth=79;
       screenheight=23;
     var
       clear:char;
       a:array[1..16] of char;
       xpos,ypos:real;

 procedure plotstep(step:char);
   external;

 procedure plotinit; (*sets up usart for plotter*)
   external;

 procedure plotline;
   var
     z,x,y,f,d,i,t,e:integer;

   procedure initplot;
     begin
```

Listing 1 continued on page 224

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Listing 1 continued:

```
    clear:=chr(26);
    write(clear);
    gotoxy((screenwidth-47) div 2,screenheight div 2-1);
    write('Please type [ret] when plot pen is at the lower');
    gotoxy((screenwidth-26) div 2,screenheight div 2);
    write('left corner of plotter bed');
    readln;
    write(clear);
    plotinit;
    xpos:=0.0;
    ypos:=0.0;

    a[1]:='p';a[2]:='q';a[3]:='r';a[4]:='q';a[5]:='r';a[6]:='s';
    a[7]:='t';a[8]:='s';a[9]:='t';a[10]:='u';a[11]:='v';
    a[12]:='u';a[13]:='v';a[14]:='w';a[15]:='p';a[16]:='w';
    plotline(1,0,0);
  end;(*initplot*)

begin(*plotline*)
  case penpos of
    0:initplot;
    1:plotstep('y');
    2:plotstep('z');
  end;
  if penpos=0 then exit(plotline);
  if (xplot>10.25) or (xplot<-0.25) or (yplot>7.25)
   or (yplot<-0.25) then
    begin
      write(clear);
      gotoxy((screenwidth-49) div 2,screenheight div 2-1);
      writeln('Plotline: Plot attempted off page ('
        ,xplot:6:2,',',yplot:6:2,')');
      gotoxy((screenwidth-17) div 2,screenheight-1);
      write('Please type [ret]');
      readln;
      write(clear);
      exit(plotline);
    end;
  x:=round((xplot-xpos)*200);
  y:=round((yplot-ypos)*200);
  xpos:=xpos+x/200;
  ypos:=ypos+y/200;

  (*This section is translated from Houston Instrument *)

  f:=abs(x)+abs(y);
  if f=0 then exit(plotline);
  d:=abs(y)-abs(x);
  i:=0;
  if y>=0 then i:=2;
  t:=x+y;
  if t>=0 then i:=i+2;
  t:=y-x;
  if t>=0 then i:=i+2;
  if x<0 then i:=i+10
  else i:=8-i;
  if d<0 then t:=abs(y)
  else
    begin
      t:=abs(x);
      d:=-d;
    end;
  e:=0;
  repeat
    z:=t+d+e+e;
    if z<0 then
      begin
        e:=e+t;
        f:=f-1;
        plotstep(a[i-1]);
      end
    else
      begin
        e:=e+d;
        f:=f-2;
        plotstep(a[i]);
      end;
  until f<=0;
end;(*plotline*)

procedure plotstring;
  var
    step1,xstep1,ystep1,x2step1,y2step1,x3step1,y3step1,
    step,xstep,ystep,x2step,y2step,x3step,y3step:real;
    j,n:integer;

  procedure plotchar(ch:char);
    var
      rxpos,rypos:real;
```

Listing 1 continued on page 226

Listing 1 continued:

```
  plot:string[32];
  pchar:char;
  i:integer;

procedure arrow;
  begin
    stepl:=0.04;
    xstepl:=stepl*cos(theta);
    ystepl:=stepl*sin(theta);
    x2stepl:=sqrt(2)*stepl*cos(theta+pi/4);
    y2stepl:=sqrt(2)*stepl*sin(theta+pi/4);
    x3stepl:=sqrt(2)*stepl*cos(theta-pi/4);
    y3stepl:=sqrt(2)*stepl*sin(theta-pi/4);
    plotline(2,xpos-y2stepl,ypos+x2stepl);
    plotline(2,xpos+ystepl,ypos-xstepl);
    plotline(2,xpos+ystepl,ypos-xstepl);
    plotline(2,xpos-y3stepl,ypos+x3stepl);
    exit(plotchar);
  end;(*arrow*)

procedure getcode;
  begin
    case ch of

      'A','a':plot:='d888889oolkkkkkaaaawwwwooooi';
      'B','b':plot:='d888888ooolkjuuuooolkkjuuui';
      'C','c':plot:='ddddwjuu788889ooli';
      'D','d':plot:='d888888ooolkkkkjuuui';
      'E','e':plot:='ddddduuuu888oouu888ooooi';
      'F','f':plot:='d8888oouu888ooooi';
      'G','g':plot:='ddddwwwwww7uujkkkkkloo988uui';
      'H','h':plot:='d888888ddddkkkkkkkwwwwuuuui';
      'I','i':plot:='dooouu888888uuooooi';
      'J','j':plot:='dwloo988888i';
      'K','k':plot:='d888888dddjjjlllli';
      'L','l':plot:='ddddduuuu888888i';
      'M','m':plot:='d888888llkk8899kkkkkkki';
      'N','n':plot:='d888888lllllwwwwkkkkkkki';
      'O','o':plot:='dd788889oolkkkkkjuui';
      'P','p':plot:='d888888ooolkkjuuui';
      'Q','q':plot:='dd788889oolkkkkkjuudwwlli';
      'R','r':plot:='d888888ooolkkjuuuooolkki';
      'S','s':plot:='dwloo9887uu789ooli';
      'T','t':plot:='ddd888888aaooooi';
      'U','u':plot:='dwwwwwwkkkkkloo988888i';
      'V','v':plot:='dwwwwwwkkkkll998888i';
      'W','w':plot:='dwwwwwwkkkkkkk9988kkll888888i';
      'X','x':plot:='d889999aaaakllllkki';
      'Y','y':plot:='dwwwwwwkll998kjjkkkki';
      'Z','z':plot:='dwwwwwwooookjjjjkkooooi';
      '.':plot:='ddd8okui';
      '=':plot:='ddwwoooowwuuuui';
      '>':plot:='d999777i';
      '<':plot:='dddd777999i';
      '$':plot:='dwwooo97uu79ooowaakkkkkki';
      '!':plot:='oooooo!i';
     end;(*case*)
  end;(*getcode*)

procedure getcode2;
  begin
    case ch of
      '*':plot:='dww9999aakkkkdd7777xxooooi';
      '/':plot:='d889999i';
      '"':plot:='dw9999aaaku8oxxxxd8ok8okuui';
      '?':plot:='ddd8w8997uujki';
      '#':plot:='ddddwwwww8okui';
      '&':plot:='dddwwwwkkuu88ooooxaooakki';
      ',':plot:='ddd8okuoji';
      '1':plot:='dwwwww99kkkkkkuuooooi';
      '2':plot:='dwwwwww9oolkkjjjjooooi';
      '3':plot:='dwwwwww9ooojjjoolkkjuu7i';
      '4':plot:='dwwwwwwwkkkkooooawwwwkkkkkkki';
      '5':plot:='ddddwwwwwwwwuuuukkkooolkkjuu7i';
      '6':plot:='ddddwwwwww7uujkkkkkloo9887uuji';
      '7':plot:='dwwwwww8ooookjjkkkki';
      '8':plot:='ddwwww789oolkjuujkkloo9887i';
      '9':plot:='dwloo988887uujkkloo9i';
      '0':plot:='dd788889oolkkkkkjuui';
      '(':plot:='dddd7788899i';
      ')':plot:='dd998877i';
      '%':plot:='dw9999aaauko8xxxxddo8uki';
      '+':plot:='dddww8888aaxxooooi';
      '-':plot:='dwwwwooooi';
      ':':plot:='ddwwo8ukwwo8uki';
      '[':plot:='1i';
      ']':plot:='2i';
    end;(*case*)
end;(*getcode2*)
```

Listing 1 continued on page 228

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Listing 1 continued:

```
    begin(*plotchar*)
      rxpos:=xpos;
      rypos:=ypos;
      plot:='i';
      getcode;
      getcode2;
      i:=1;
      pchar:='0';
      while pchar<>'i' do
        begin
          pchar:=plot[i];
            case pchar of
              'd':plotline(1,xpos+xstep,ypos+ystep);
              'w':plotline(1,xpos-ystep,ypos+xstep);
              'a':plotline(1,xpos-xstep,ypos-ystep);
              '7':plotline(2,xpos-x3step,ypos-y3step);
              '8':plotline(2,xpos-ystep,ypos+xstep);
              '9':plotline(2,xpos+x2step,ypos+y2step);
              'o':plotline(2,xpos+xstep,ypos+ystep);
              'l':plotline(2,xpos+x3step,ypos+y3step);
              'k':plotline(2,xpos+ystep,ypos-xstep);
              'j':plotline(2,xpos-x2step,ypos-y2step);
              'u':plotline(2,xpos-xstep,ypos-ystep);
              'x':plotline(1,xpos+ystep,ypos-xstep);
              '|':arrow;
              '!':begin
                   rxpos:=rxpos-(height/2)*sin(theta)-
                           6*xstep;
                   rypos:=rypos+(height/2)*cos(theta)-
                           6*ystep;
                 end;
              '2':begin
                   rxpos:=rxpos+(height/2)*sin(theta)-
                           6*xstep;
                   rypos:=rypos-(height/2)*cos(theta)-
                           6*ystep;
                 end;
            end;(*case*)
          i:=i+1;
        end;(*while*)
        plotline(1,rxpos+6*xstep,rypos+6*ystep);
    end;(*plotchar*)

  begin(*plotstring*)
    theta:=(theta/360)*2*pi;
    step:=height/7;
    xstep:=step*cos(theta);
    ystep:=step*sin(theta);
    x2step:=sqrt(2)*step*cos(theta+pi/4);
    y2step:=sqrt(2)*step*sin(theta+pi/4);
    x3step:=sqrt(2)*step*cos(theta-pi/4);
    y3step:=sqrt(2)*step*sin(theta-pi/4);
    n:=length(line);
    plotline(1,px,py);
    for j:=1 to n do
      plotchar(line[j]);
  end;(*plotstring*)

procedure plotsymbol;
  var
    rxpos,rypos:real;
  begin
    rxpos:=xpos;
    rypos:=ypos;
    case sym of
      1:begin (*triangle*)
          plotline(2,xpos,ypos+height/2);
          plotline(2,xpos-height/2,ypos-height);
          plotline(2,xpos+height,ypos);
          plotline(2,xpos-height/2,ypos+height);
          plotline(1,rxpos,rypos);
        end;
      2:begin (* X *)
          plotline(1,xpos-height/2,ypos+height/2);
          plotline(2,xpos+height,ypos-height);
          plotline(1,xpos-height,ypos);
          plotline(2,xpos+height,ypos+height);
          plotline(1,rxpos,rypos);
        end;
      3:begin (*square*)
          plotline(2,xpos,ypos+height/2);
          plotline(2,xpos-height/2,ypos);
          plotline(2,xpos,ypos-height);
          plotline(2,xpos+height,ypos);
          plotline(2,xpos,ypos+height);
           plotline(2,xpos-height/2,ypos);
           plotline(1,rxpos,rypos);
         end;
       4:begin (* + *)
```

Listing 1 continued on page 230

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Listing 1 continued:

```
          plotline(2,xpos+height/2,ypos);
          plotline(2,xpos-height,ypos);
          plotline(2,xpos+height/2,ypos);
          plotline(2,xpos,ypos+height/2);
          plotline(2,xpos,ypos-height);
          plotline(2,rxpos,rypos);
        end;
      5:begin (*vertical line*)
          plotline(2,xpos,ypos+height/2);
          plotline(2,xpos,ypos-height);
          plotline(2,rxpos,rypos);
        end;
    end;(*case*)
  end;(*plotsymbol*)

procedure plotwhere;
  begin
    px:=xpos;
    py:=ypos;
  end;

procedure plotarray;
  var
    pen,i:integer;
  begin
    if nopoints>250  then
      begin
        write(clear);
        gotoxy((screenwidth-42) div 2,screenheight div 2);
        writeln('Plotarray: Plot attempted with >250 points');
        gotoxy((screenwidth-17) div 2,screenheight-1);
        write('Please type [ret]');
        readln;
        write(clear);
        exit(plotarray);
      end;
    if (py+ylen>7.0) or (px+xlen>10) then
      begin
        write(clear);
        gotoxy((screenwidth-50) div 2,screenheight div 2-1);
        writeln('Plotarray: Plot attempted off page (',
        px+xlen:6:2,',',py+ylen:6:2,')');
        gotoxy((screenwidth-17) div 2,screenheight-1);
        write('Please type [ret]');
        readln;
        write(clear);
        exit(plotarray);
      end;
    xlen:=(xmax-xmin)/xlen;
    ylen:=(ymax-ymin)/ylen;
    if freq<0 then pen:=1
    else pen:=2;
    freq:=abs(freq);
    plotline(1,((x[1]-xmin)/xlen)+px,((y[1]-ymin)/ylen)+py);
    if freq>0 then plotsymbol(sym,height);
    for i:=2 to nopoints do
      begin
        plotline(pen,((x[i]-xmin)/xlen)+px,
          ((y[i]-ymin)/ylen)+py);
        if (freq>0) then
          if ((i+1) mod freq=0) then plotsymbol(sym,height);
      end;
  end;(*plotarray*)

procedure plotaxis;
  var
    temp1,side:integer;
    print:boolean;
    amount:string;
    theta1,temp,rxpos,rypos,len,per,step:real;

  procedure divsteps(theta:real);
    begin
      theta:=theta+pi/2;
      plotline(2,xpos+0.03*cos(theta),ypos+0.03*sin(theta));
      plotline(2,xpos-0.06*cos(theta),ypos-0.06*sin(theta));
      plotline(2,xpos+0.03*cos(theta),ypos+0.03*sin(theta));
    end;

  begin(*plotaxis*)
    if tic<0 then
      begin
        tic:=-tic;
        side:=-1;
      end
    else
      side:=1;
    theta1:=theta;
    theta:=(2*pi/360)*theta;
```

Listing 1 continued on page 232

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Listing 1 continued:

```
    if (px+leng*cos(theta)>10) or (py+leng*sin(theta)>7) then
      begin
        writeln('Plotaxis: plot attempted off page (',
          px+leng*cos(theta),',',py+leng*sin(theta),')');
        write('Please type [ret]');
        readln;
        exit(plotaxis);
      end;
    if leng<0 then
      begin
        print:=false;
        leng:=-leng;
      end
    else
      print:=true;
    len:=leng;
    plotline(1,px,py);
    per:=(leng-0.01)/(max-min);
    while leng>0 do
      begin
        if leng>tic*per then step:=tic*per
        else step:=leng;
        divsteps(theta);
        if print then
          begin
            rxpos:=xpos;
            rypos:=ypos;
            templ:=trunc(min*100);
            str(templ,amount);
            insert('.',amount,length(amount)-1);
            temp:=length(amount)/2;
            plotline(1,xpos-(0.086*temp*cos(theta)-
            side*(0.14+(side-1)*0.05)*sin(theta)),
            ypos-(0.086*temp*sin(theta)+side*(0.14+(side-1)*0.05)
            *cos(theta)));
            plotstring(xpos,ypos,0.1,thetal,amount);
            plotline(1,rxpos,rypos);
          end; (*if*)
        plotline(2,xpos+step*cos(theta),ypos+step*sin(theta));
        leng:=leng-step;
        min:=min+tic;
      end; (*while*)
    if print then
      begin
        plotline(1,
        xpos-(len/2*cos(theta)+0.108*round(length(name)/2)
          *cos(theta)-side*(0.35+(side-1)*0.075)*sin(theta)),
        ypos-(len/2*sin(theta)+0.108*round(length(name)/2)
          *sin(theta)+side*(0.35+(side-1)*0.075)*cos(theta)));
        plotstring(xpos,ypos,0.125,thetal,name);
      end;
  end; (*plotaxis*)
end. (*unit*)
```

Listing 2: *A demonstration Pascal program that uses the "plotter" unit. The plot drawn by this program is shown in figure 3.*

```
program plotter_demo;
 uses plotter;

 const
   pi=3.14159;

 var
   index:integer;
   xpoints,sinypoints,cosypoints:coord;
   xloc,yloc,angle:real;

 begin

   (*this segment initializes the arrays*)

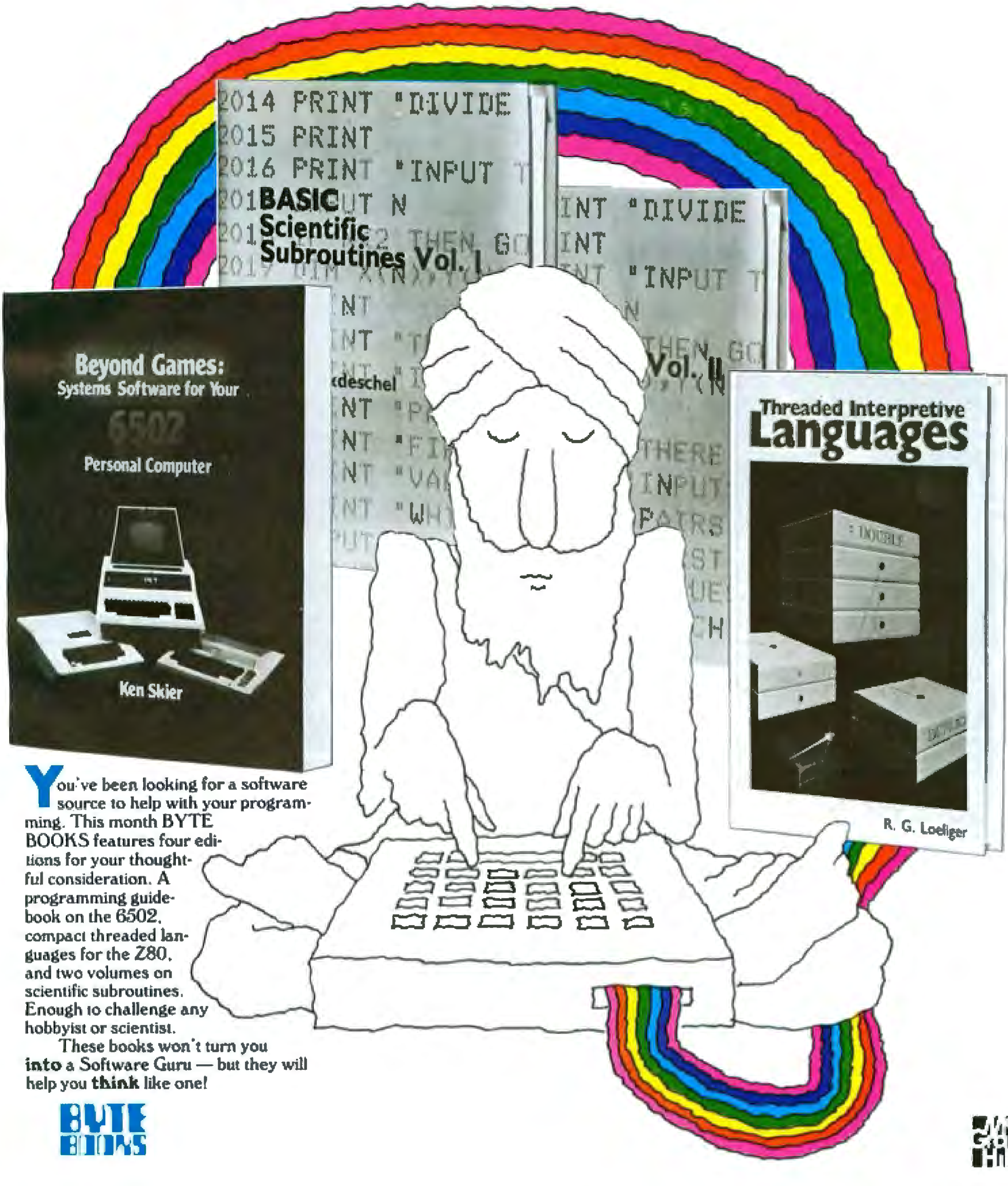
   for index:=1 to 250 do
     begin
       angle:=(index-1)/249*2*pi;
       xpoints[index]:=index-1;
       sinypoints[index]:=sin(angle);
       cosypoints[index]:=cos(angle);
     end;

   (*this segment does the plotting*)

   plotline(0,0,0);
   plotstring(3,6.75,0.126,0,'this is a demonstration of the plotter unit');
   plotaxis(0.5,0.5,9.5,0,0,36,6,'angle (in degrees) *10[-1]');
```

Listing 2 continued on page 238

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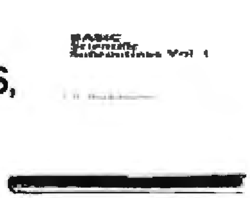
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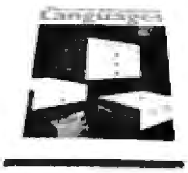
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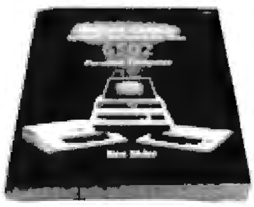
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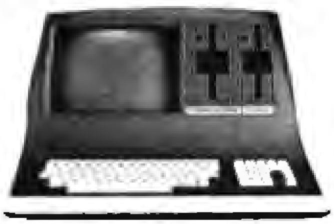


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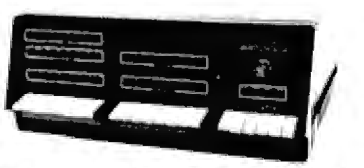
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Listing 2 continued:

```
  plotaxis(0.5,0.5,5.75,90,-1,1,-0.5,'magnitude');
  plotarray(250,-10,3,0.5,0.5,0,249,-1,1,0.07,9.5,5.75,xpoints,sinypoints);
  plotarray(250,10,2,0.5,0.5,0,249,-1,1,0.07,9.5,5.75,xpoints,cosypoints);
  plotline(1,5.5,6.25);
  plotsymbol(3,0.126);
  plotwhere(xloc,yloc);
  plotstring(xloc+0.25,yloc-0.126/2,0.126,0,'- sine');
  plotline(1,5.5,5.75);
  plotsymbol(2,0.126);
  plotwhere(xloc,yloc);
  plotstring(xloc+0.25,yloc-0.126/2,0.126,0,'- cosine');
end.
```

Listing 3: *The machine-language procedure "plotstep". This procedure, which is dependent on the hardware implementation given in the text, transmits pen-movement commands to the Hiplot plotter through its associated output port.*

```
                .PROC PLOTSTEP,1
                .PRIVATE PENPOS,RETADDR
STATUS          .EQU 07DH
PLOTCMD         .EQU 7CH
UPCMD           .EQU 79H
DNCMD           .EQU 7AH
UP              .EQU 0FFH
DOWN            .EQU 00H
                POP HL              ;GET RETURN ADDRESS
                LD (RETADDR),HL     ;LOAD RETURN ADDRESS
                POP BC              ;GET CHARACTER
PLOTOUT         IN A,(STATUS)       ;INPUT STATUS
                AND 1               ;MASK STATUS BIT
                JP Z,PLOTOUT        ;WAIT FOR READY
                LD A,C              ;GET PLOT CHARACTER
                OUT (PLOTCMD),A     ;PLOT IT
                CP UPCMD            ;PEN UP?
                JP Z,PENUP          ;YES, TIME IT OUT
                CP DNCMD            ;PEN DOWN?
                JP Z,PENDN          ;YES, TIME IT OUT
                LD A,(PENPOS)       ;GET PEN POSITION
                CP UP               ;UP?
                JP Z,EXIT           ;YES, RETURN
                LD B,00H            ;LOAD TIMER
                LD C,80H            ;LOAD TIMER
                CALL TIMER
                JP EXIT             ;RETURN
TIMER           DEC BC              ;DECREMENT TIMER
                LD A,B              ;GET TIMER HIGH
                CP 00H              ;ZEROED OUT?
                JP Z,TIMER1         ;YES, TIME FURTHER
                JP TIMER            ;NO, DO IT AGAIN
TIMER1          LD A,C              ;GET TIMER LOW
                CP 00H              ;TIMED OUT?
                JP Z,EXIT           ;YES, RETURN
                JP TIMER            ;CONTINUE TIMING
PENUP           LD A,(PENPOS)       ;CHECK PEN POSITION
                CP UP               ;UP?
                JP Z,EXIT           ;YES, RETURN
                LD A,UP             ;SET PENPOS UP
                LD (PENPOS),A       ;PENPOS UP
                LD B,02H            ;NO, TIME OUT
                CALL TIMER
                JP EXIT
PENDN           LD A,(PENPOS)       ;CHECK PEN POSITION
                CP DOWN             ;DN?
                JP Z,EXIT           ;YES, RETURN
                LD A,DOWN           ;SET PENPOS DN
                LD (PENPOS),A       ;PENPOS DN
                LD B,02H            ;NO, TIME OUT
                CALL TIMER
EXIT            LD HL,(RETADDR)     ;GET RETURN ADDRESS
                JP (HL)             ;RETURN
                .END
```

Listing 4: *The machine-language procedure "plotinit". This procedure initializes the serial output port at the beginning of a drawing session. It is dependent on the specific hardware used in the author's system.*

```
.PROC PLOTINIT
LD A,05H
OUT (78H),A
LD A,01H
OUT (78H),A
RET                 ;RETURN
.END
```

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Text continued from page 222:
point. The characters "[" and "]", when passed in a string, cause subscripts and superscripts to be plotted. Any characters enclosed in brackets (eg: this is a [superscript]) will be plotted spaced up one half the height of the characters, and any character enclosed in "unbrackets" (eg: this is a]subscript[) will be plotted spaced a similar distance below the current line.

The plotting of arrows is another special case. If an arrow is to be plotted, it will be plotted with a height as specified in the parameter passed to "plotstring", but the head of the arrow will always be of the same size. Thus, arrows can be plotted representing, for example, the strength of the current in a given circuit, with the length of the arrow being proportional to the current.

If you want to generate any special characters of your own, it is a simple matter to decide on the shape of the character (which, by the way, must reside within a "box" 7 moves high by 4 moves wide) and generate it by coding the appropriate moves using the two vector pads I described above. The characters I have already encoded are shown in figure 2.

The procedure "plotwhere" is used to locate the pen on the plotting bed. It is passed two real variables and returns them loaded with the current *x* and *y* locations of the plotting pen. This procedure is useful when you want to add a comment or identifying remark to a point or line being drawn on the plot. Simply call "plotwhere", displace the pen an appropriate distance from the current pen position, plot the comment, and return the pen to its initial position.

Graph-Plotting Procedures

The procedure "plotarray" is rather complicated. It is used to plot an array of up to 256 points. Of course, plotting more than that number of points can be done by calling it more than once. The procedure is passed the number of points to be plotted, the frequency of any identifying symbol to be plotted, the identifier of the symbol to be used, the beginning point of the plot, the range of the *x* and *y* variables, the height of the symbols, the area the plot is to occupy, and, last but not least, the two arrays (of type "coord") that contain the *x* and *y* coordinates of the desired plot.

This may seem like a large number of parameters to be passing to the procedure, but it allows for a great deal of flexibility in plotting arrays and is, in fact, easier to use in practice than it is to describe. What "plotarray" does is to simply scale the location of the points passed to it and fit them into the space indicated. It then moves the pen to the series of (*x*,*y*) points given by the two arrays of "coord"s, with the pen either up or down, depending upon the sign of the frequency of symbols passed. If the frequency of symbols is passed as 0, no identifying symbols will be plotted; if it is 1, every point will be identified; if it is 2, every other point, and so on. If frequency is negative, only the points will be plotted, with no interconnecting lines. As implemented, the points can be identified by five different symbols: triangle, X, square, +, or vertical line. These are selected by passing the symbol as 1, 2, 3, 4, or 5, respective-

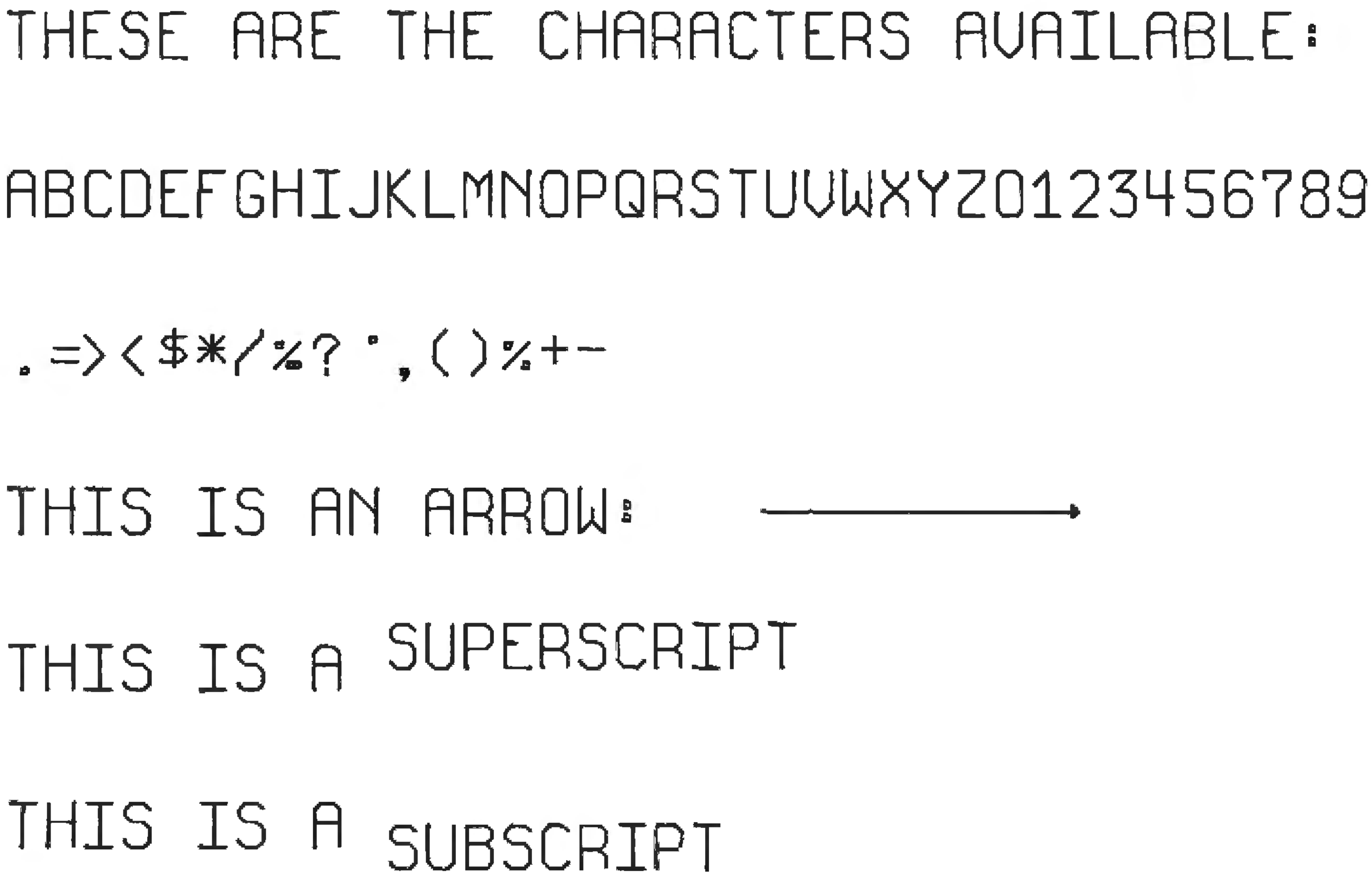


Figure 2: *An example showing the letters, special characters, and plotting options available through the "plotstring" procedure.*

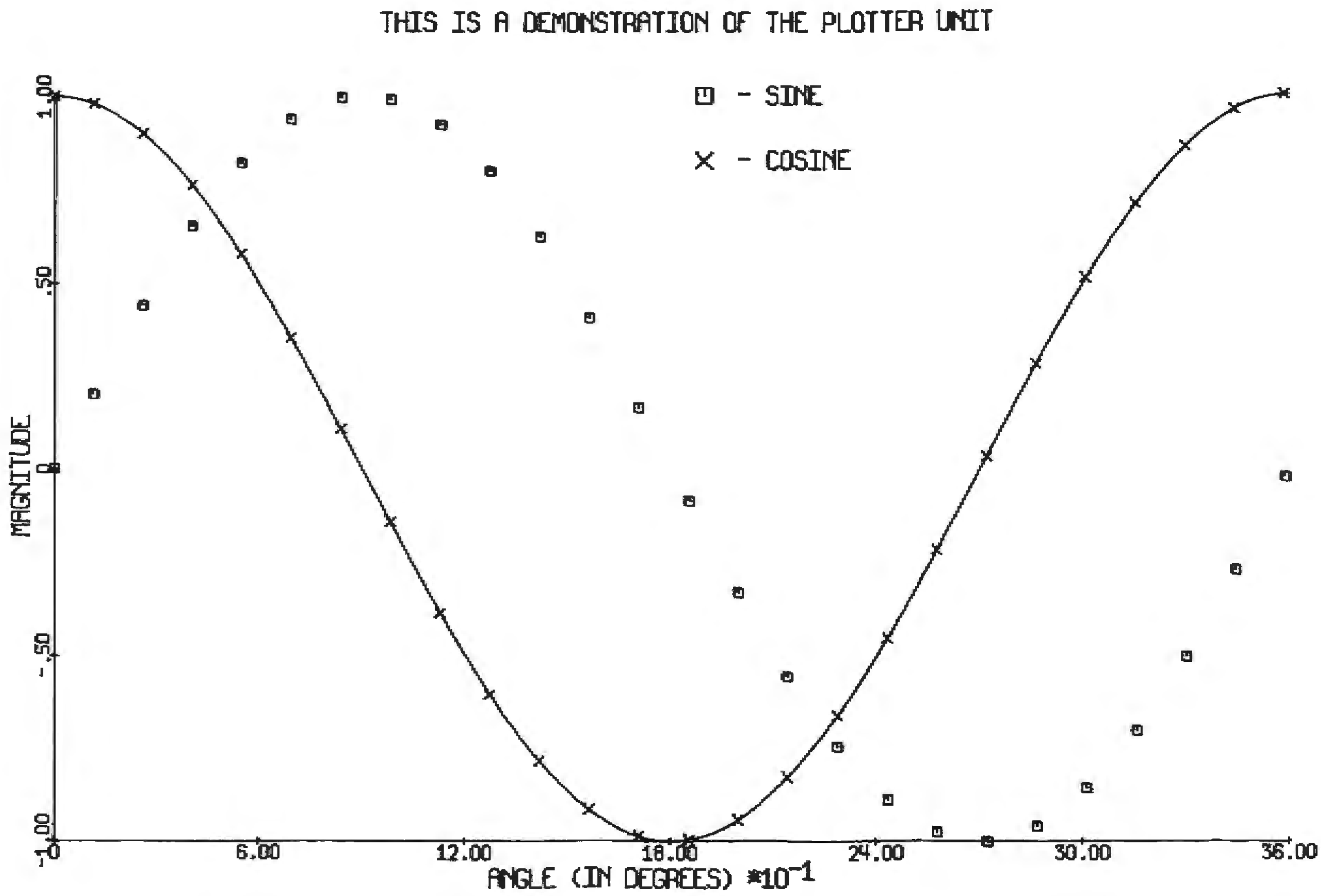


Figure 3: *A demonstration of the Hiplot plotter driven by a Pascal program (see listing 2) and the "plotter" unit (given in listing 1).*

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ly. The size of the plotted symbol is passed in the height variable.

The procedure "plotsymbol" is used to plot any of the five identifying symbols. These symbols are used in procedure "plotarray" if some identifying point marker is desired. The procedure is passed integers that identify the symbol to be plotted and the height of the desired symbol. The symbol will be plotted centered at the current pen position. This procedure can be used both to identify points on a plot and in a description of the meaning of those points (see the example plot in figure 3 and listing 2).

The procedure "plotaxis" is used to plot an axis with its identification and values. It is most often used in conjunction with "plotarray" to plot experimental data but, of course, can be used in any other way for special purposes. The procedure is passed the location of the origin of the axis, its length in inches, the angle of the axis with respect to the long axis of the plotting paper, the minimum and maximum values represented on the axis, how often tic marks should occur on the axis, and the name of the axis. If length is passed as negative, no labeling of tic marks or axis will occur. If the tic-mark value is passed as negative, the labeling of both axis and tic marks is done on the counterclockwise side of the axis. This last step is included so labels on axis can be put on the "outside" of the plot area in the case of two-axis plots (see the example plot).

I should mention here that there is a limitation on the size of tic-mark labels. A floating-point error will be generated if you try to make any label larger than ±327.67. This is because integer arithmetic is used to translate from the floating-point number to the string variable plotted as the tic-mark label. An easy way around this is to do it as I did in the sample plot and use a factor-of-ten multiplier in the axis label to compensate (see figure 3).

The plot in figure 3 with its accompanying listing demonstrates how the plotter subroutines can be used to generate a plot with a minimum of programming effort.

Implementation Details

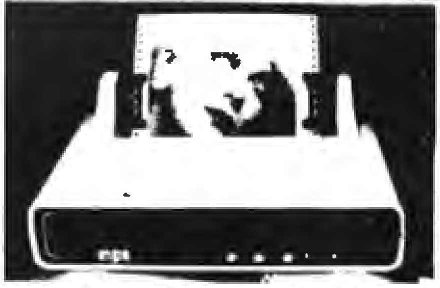
These plotter procedures were developed using an SD Systems SBC-100 microprocessor board and a VDB-8024 video board. If they are to be used on systems other than the one described, a few modifications will have to be made. The constants "screenwidth" and "screenheight" defined in the "const" section of the implementation section in listing 1 should be changed to reflect the size of your own screen, and the character variable "clear", defined in procedure "initplot", should be changed to reflect the character that causes your screen to be cleared. Thus, it will only be necessary for you to write your own "plotstep" and "plotinit" subroutines for the "plotter" unit so it is functional on your computer.

I'm not familiar with other plotters, but I suspect that these procedures might be usable on other machines after the appropriate modifications to procedures "plotstep" and "plotline" have been made.

If you would like a copy of the source for these plotter programs, I'd be happy to supply it. Just send me a blank 8-inch floppy disk and $10, and I will return it to you with the source code for all of the programs described in this article. ■

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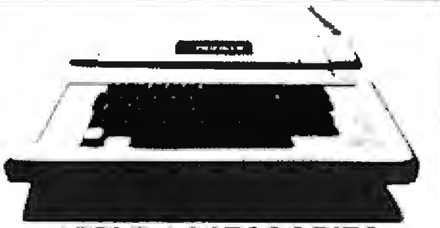
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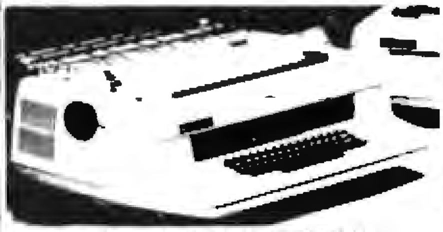


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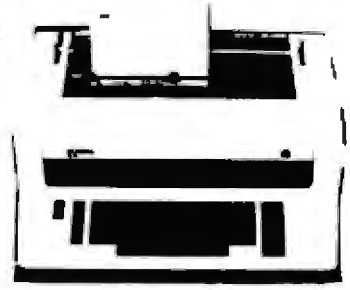
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Conserve Energy with Your Computer

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As we are all too well aware, the cost of heating a home has skyrocketed in recent years. Many homeowners, searching for ways to improve the energy efficiency of their homes, add insulation to the walls or roof, install storm windows, or caulk and weather-strip around windows and doors. Money is spent on one or more of these energy-conservation plans only because homeowners expect a reasonable return on their investment in the form of lower heating bills.

Many homeowners, however, will spend a great deal of money on insulation for the walls or ceiling, for example, without having any idea how much their heating costs will actually be reduced. At some thickness, adding more insulation is no longer cost-effective. The "proper" thickness is very difficult to determine. Also, if a house has heat losses through single-pane windows or air leaks from poor weather stripping, adding insulation to the walls will not do much to reduce the overall heat loss. In short, homeowners usually suffer from a lack of information on the thermal properties and energy efficiency of their homes.

There are two basic ways to find the energy savings and return on money invested with a home heating energy-conservation plan:

- Choose a plan, have it done, and wait for the heating bills to arrive to determine actual energy savings.
- Choose a plan and analyze the energy-efficiency improvement to find the energy savings before spending money.

To analyze the energy-efficiency improvement, such factors as climate, existing insulation, and building dimensions must be determined, as well the heat-transfer properties of all exposed surfaces. Inasmuch as each house has unique and complex heat-loss characteristics, any analysis will be somewhat involved.

Listing 1 (see page 258) is a computer program to evaluate the physical properties of a house. The program analyzes and displays heat loss through each exposed building element (walls, windows, etc) and provides the computed heat losses associated with a selected heating energy-conservation plan. The program will run on the Radio Shack TRS-80 Model 1 and, with few changes, it can be adapted to most small computers. With this program, the most efficient heating energy-conservation plan can be selected, and the approximate return on investment can be derived from the computed heating-cost savings. Fundamental to this program is the supposition that any heating energy-conservation plan is properly done (i.e., insulation evenly distributed with proper vapor barriers, or good construction practices for installing storm windows or adding weather stripping).

Figure 1 (see page 252) includes a worksheet and an exploded drawing of a typical house. The worksheet and drawing are an aid to help in organizing the required data before working with the computer. The first part of the worksheet asks for the surface area of all exposed building elements through which heat can escape. The second part asks for the thickness and R-factor of insulation already present in the walls, roof, or ceiling. (The R-factor is a measure of how well a material will insulate. The higher the R-factor, the greater the effective insulation.) If the attic is heated, the thickness of insulation in

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Worksheet

Exposed Surface Areas	Calculation	Sample House: Calculation	Sample House: Area in Square Feet	Your House: Calculation	Your House: Area in Square Feet
Total Window Area (N = Number of Windows)					
With Double Panes	N × h × w	11×3×4 =	132		
With Single Panes	N × h × w	1×5½×12=	66		
		Total	198	Total	
Total Wall Area	(2 × W × H) + (2 × L × H) − Total Window Area	(2×30×20)+ (2×50×20)− 198=	3002		
Total Roof/Ceiling Area					
Roof—If Attic Is Heated	(2 × L × S) + (W × A)				
Ceiling—If Attic Is Unheated	L × W	50 x 30 =	1500		
Total Door Area (N = Total Number of Doors)	N × h × w	2×7×3 =	42		
Existing Insulation		Thickness In Inches	R-Factor (table 1)	Thickness In Inches	R-Factor (Table 1)
Insulation in Walls		2	9		
Insulation in Roof/Ceiling	Roof	3	11		
	Ceiling*	2	9		
	Total	5	20		

*If attic is heated, disregard ceiling insulation.

Sample House

structure:
- H = 20 feet
- W = 30 feet
- L = 50 feet
- A = 6 feet
- S = 16

S can be calculated from A and W:
$S = \sqrt{W^2/4 + A^2}$

typical window:
- h = 3 feet
- w = 4 feet

picture window:
- h = 5½ feet
- w = 12 feet

typical door:
- h = 7 feet
- w = 3 feet

- ceiling insulation thickness = 2 inches
- roof insulation thickness = 3 inches
- wall insulation thickness = 2 inches

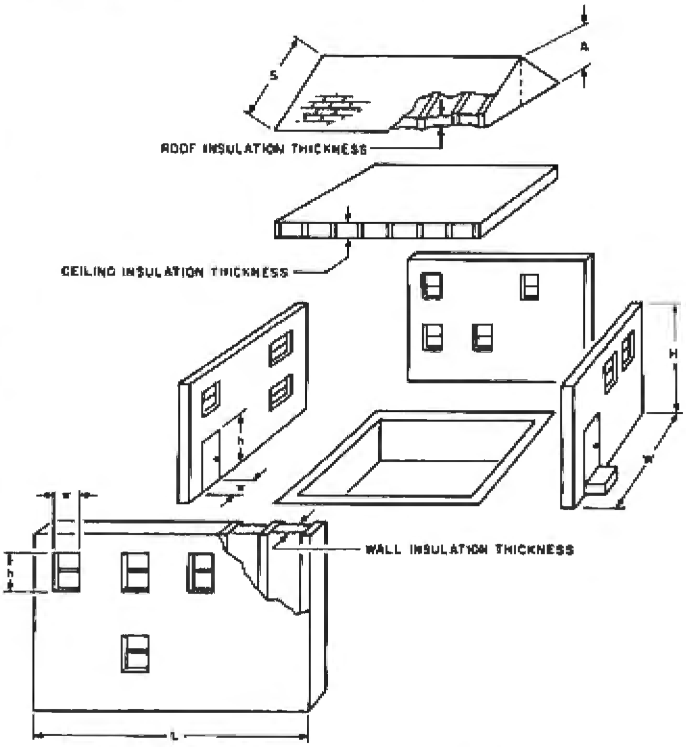


Figure 1: *Worksheet and exploded view of house. Data for the sample house is entered here in figure 1a, and the resulting output for two plans is shown in figure 3. Use a photocopy of the blank worksheet (figure 1b) to help organize your data before entering it into the computer.*

Worksheet

		Sample House		Your House	
Exposed Surface Areas	Calculation	Calculation	Area in Square Feet	Calculation	Area in Square Feet
Total Window Area (N = Number of Windows)					
With Double Panes	N × h × w				
With Single Panes	N × h × w				
		Total		Total	
Total Wall Area	(2 × W × H) + (2 × L × H) – Total Window Area				
Total Roof/Ceiling Area					
Roof—If Attic Is Heated	(2 × L × S) + (W × A)				
Ceiling—If Attic Is Unheated	L × W				
Total Door Area (N = Total Number of Doors)	N × h × w				
Existing Insulation		Thickness in Inches	R-Factor (table 1)	Thickness in Inches	R-Factor (Table 1)
Insulation in Walls					
Insulation in Roof/Ceiling	Roof				
	Ceiling*				
	Total				

*If attic is heated, disregard ceiling insulation.

Figure 1b: *Blank worksheet to help you organize data before calculating your home's energy efficiency.*

the roof and the roof's surface area are entered in the worksheet (ceiling area and insulation do not apply since the ceiling is not exposed to the cold). If the attic is unheated, the ceiling surface area and the combined thickness of insulation in the roof and ceiling are entered in the worksheet (both the roof and ceiling insulation help to reduce the heat flow to the outside). The insulation R-factor is found by checking the thickness and type of insulation in table 1. (See page 254.) For houses with odd shapes, heated annexes, or unheated garages inside the house, the surface area of each wall, window, and so forth exposed to the cold should be added to find the individual total wall, roof, window, and door areas.

Try an Example

The sample house shown in figure 1 is located in Chicago, Illinois, which is situated in heating region number 4 on the map in figure 2. (See page 254.) When the physical characteristics of this house are entered as shown in the program operation section, the heat-loss profile in figure 3a (see page 256) is displayed. This profile shows that most of the heat is lost through the walls. Because the existing roof and ceiling of the sample house are comparatively well insulated, and the sample house has storm windows, I will plan to add 2 inches of loose rockwool (R-factor 9 in table 1) to all the walls.

Figure 3b is the computed heat-loss profile with the added insulation in the walls. It shows that substantially less heat is lost through the walls with this plan. The overall heat-loss reduction is 21%, and, since the annual heating cost for the sample house is $900, the yearly saving with this plan is $191. It must be considered, however, that adding insulation to the walls can be very expensive. If pumping loose fill into all walls costs $2000, the return on investment is about 9% for the first year for this example (approximately a 10-year breakeven point with *constant* heating fuel costs). The program operation is shown in figure 4. (See page 260.)

In the sample house, an inspection of the caulking and weather stripping

around windows and doors reveals noticeable drafts and dried-out caulk material. The caulking and weather stripping improvement plan is evaluated next. The results (figure 3c) show that the total heat-loss reduction is about 12% (or $112 annually) with the new caulking and weather stripping plan. In the example, this plan costs about $200, and the return on investment for the first year is 60% (about a two-year breakeven point).

It is apparent that the caulking and weather stripping plan offers a better return on investment. Assuming that heating fuel costs will increase, however, our wall-insulation plan and other costly improvement plans become more attractive each year. Also, air-conditioned homes will ben-

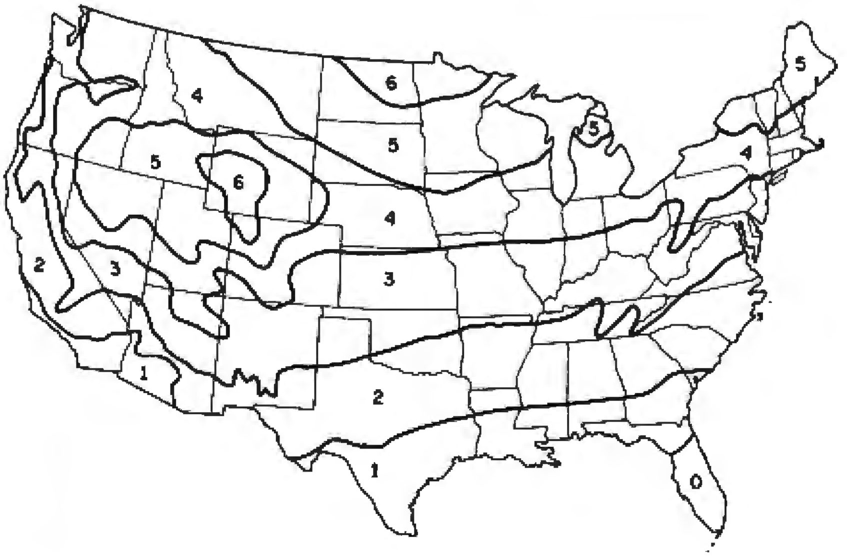


Figure 2: *Six heating zones in the continental United States. These play an important part in figuring your heat loss. For other areas, consult your local government. (Source: United States Department of Commerce, National Bureau of Standards.)*

	Batts or Blankets		Loose Fill		
R-Factor	Glass Fiber	Rock Wool	Glass Fiber	Rock Wool	Cellulose Fiber
4	Wall with no insulation				
6	Roof/ceiling with no insulation				
9	2	1½-2	3	2-2	1½-2
11	3½-4	3	5	4	3
13	4	4½	6	4½	3½
19	6-6½	5½	8-9	6-7	5
22	6½	6	10	7-8	6
26	8	8½	12	9	7-7½
30	9½-10½	9	13-14	10-11	8
33	11	10	15	11-12	9
38	12-13	10½	17-18	13-14	10-11
44	14	11½	19-21	14-16	11-13

Table 1: *R-factors for various types of insulation materials. Insulation thickness is measured in inches.*

(3a) Sample House Energy-Efficiency Analysis

HEAT LOSS PROFILE

Loss through Walls	10916	BTU/HR
Loss through Roof/Ceiling	2608	BTU/HR
Loss through Windows	5280	BTU/HR
Air Infiltration Loss	4328	BTU/HR
Total Heat Loss	23133	BTU/HR

(3b)

Sample House Energy-Efficiency Improvement With Wall-Insulation Addition Plan

HEAT LOSS PROFILE WITH PLAN

Loss through Walls	6004	BTU/HR
Loss through Roof/Ceiling	2608	BTU/HR
Loss through Windows	5280	BTU/HR
Air Infiltration Loss	4328	BTU/HR
Total Heat Loss	18221	BTU/HR
Heat Loss Reduction	21%	
Annual Savings in Heating Cost =	$191	

(3c)

Sample House Energy-Efficiency Improvement With Caulking/Weather Stripping Plan

HEAT LOSS PROFILE WITH PLAN

Loss through Walls	10916	BTU/HR
Loss through Roof/Ceiling	2608	BTU/HR
Loss through Windows	5280	BTU/HR
Air Infiltration Loss	1442	BTU/HR
Total Heat Loss	20247	BTU/HR
Heat Loss Reduction	12%	
Annual Savings in Heating Cost =	$112	

Figure 3: *Energy-efficiency analysis for the sample house as provided by the program in listing 1. The heat-loss profile in based on existing conditions and represents the sample house's current total heat loss. Nearly 47% of the total heat loss is through the walls. Figure 3b shows that by adding 2 inches of loose rockwool, the total heat loss can be reduced by 21%, for an estimated annual savings of $191. On the other hand, by caulking and weather-stripping the doors and windows, a reduction of 12% of the total heat loss can be achieved at a cost of about $112. Note that these figures are based on a constant cost for heating. As the cost for heating increases, more expensive methods of improving heat loss become cost-effective.*

efit from most heating energy-improvement plans. If a house is air-conditioned, the plan with a marginally poor return on investment for heating efficiency is probably a worthwhile investment, when the total energy-efficiency improvement is considered.

Other Factors to Consider

The heat-loss properties of each house can be very complex and subject to many unknown factors. Variations in construction techniques and materials make it impossible to exactly determine heat-transfer coefficients for each building element. The heat lost from air infiltration depends on such indeterminate factors as how loose each door and window fits, outside wind speed, and what amount of time outside doors are left open when entering or exiting. Effectiveness of

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BUSINESS 100 PROGRAM LIST

NAME	DESCRIPTION
1 RULE78	Interest Apportionment by Rule of the 78's
2 ANNU1	Annuity computation program
3 DATE	Time between dates
4 DAYYEAR	Day of year a particular date falls on
5 LEASEINT	Interest rate on lease
6 BREAKEVN	Breakeven analysis
7 DEPRSL	Straightline depreciation
8 DEPRSY	Sum of the digits depreciation
9 DEPRDB	Declining balance depreciation
10 DEPRDDB	Double declining balance depreciation
11 TAXDEP	Cash flow vs. depreciation tables
12 CHECK2	Prints NEBS checks along with daily register
13 CHECKBK1	Checkbook maintenance program
14 MORTGAGE/A	Mortgage amortization table
15 MULTMON	Computes time needed for money to double, triple, etc
16 SALVAGE	Determines salvage value of an investment
17 RRVARIN	Rate of return on investment with variable inflows
18 RRCONST	Rate of return on investment with constant inflows
19 EFFECT	Effective interest rate of a loan
20 FVAL	Future value of an investment (compound interest)
21 PVAL	Present value of a future amount
22 LOANPAY	Amount of payment on a loan
23 REGWITH	Equal withdrawals from investment to leave 0 over
24 SIMPDISK	Simple discount analysis
25 DATEVAL	Equivalent & nonequivalent dated values for oblig
26 ANNUDEF	Present value of deferred annuities
27 MARKUP	% Markup analysis for items
28 SINKFUND	Sinking fund amortization program
29 BONDVAL	Value of a bond
30 DEPLETE	Depletion analysis
31 BLACKSH	Black Scholes options analysis
32 STOCVAL1	Expected return on stock via discounts dividends
33 WARVAL	Value of a warrant
34 BONDVAL2	Value of a bond
35 EPSEST	Estimate of future earnings per share for company
36 BETAALPH	Computes alpha and beta variables for stock
37 SHARPE1	Portfolio selection model-i.e. what stocks to hold
38 OPTWRITE	Option writing computations
39 RTVAL	Value of a right
40 EXPVAL	Expected value analysis
41 BAYES	Bayesian decisions
42 VALPRINF	Value of perfect information
43 VALADINF	Value of additional information
44 UTILITY	Derives utility function
45 SIMPLEX	Linear programming solution by simplex method
46 TRANS	Transportation method for linear programming
47 EOQ	Economic order quantity inventory model
48 QUEUE1	Single server queueing (waiting line) model
49 CVP	Cost-volume-profit analysis
50 CONDPROF	Conditional profit tables
51 OPTLOSS	Opportunity loss tables
52 FQUOQ	Fixed quantity economic order quantity model
53 FQEOWSH	As above but with shortages permitted
54 FQEOQPB	As above but with quantity price breaks
55 QUEUECB	Cost-benefit waiting line analysis
56 NCFANAL	Net cash-flow analysis for simple investment
57 PROFIND	Profitability index of a project
58 CAP1	Cap. Asset Pr. Model analysis of project
59 WACC	Weighted average cost of capital
60 COMPBAL	True rate on loan with compensating bal required
61 DISCBAL	True rate on discounted loan
62 MERGANAL	Merger analysis computations
63 FINRAT	Financial ratios for a firm
64 NPV	Net present value of project
65 PRINDLAS	Laspeyres price index
66 PRINDPA	Paasche price index
67 SEASIND	Constructs seasonal quantity indices for company
68 TIMETR	Time series analysis linear trend
69 TIMEMOV	Time series analysis moving average trend
70 FUPRINF	Future price estimation with inflation
71 MAILPAC	Mailing list system
72 LETWRT	Letter writing system-links with MAILPAC
73 SORT3	Sorts list of names
74 LABEL1	Shipping label maker
75 LABEL2	Name label maker
76 BUSBUD	DOME business bookkeeping system
77 TIMECLCK	Computes weeks total hours from timeclock info
78 ACCTPAY	In memory accounts payable system-storage permitted
79 INVOICE	Generate invoice on screen and print on printer
80 INVENT2	In memory inventory control system
81 TELDIR	Computerized telephone directory
82 TIMUSAN	Time use analysis
83 ASSIGN	Use of assignment algorithm for optimal job assign.
84 ACCTREC	In memory accounts receivable system-storage ok
85 TERMSPAY	Compares 3 methods of repayment of loans
86 PAYNET	Computes gross pay required for given net
87 SELLPR	Computes selling price for given after tax amount
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90 UPSZONE	Finds UPS zones from zip code
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92 AUTOEXP	Automobile expense analysis
93 INSFILE	Insurance policy file
94 PAYROLL2	In memory payroll system
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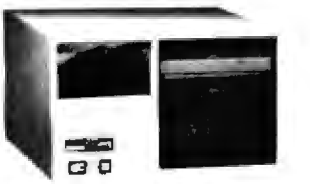
Listing 1: *A TRS-80 BASIC program to perform an energy-efficiency analysis of your home. After asking for your home's vital statistics, the program presents an analysis of your present heat losses. Then, by entering options 1 through 4, you can evaluate the results of the various energy-conservation plans on your house. Data for plans 1 and 4 for the sample house described in the text are shown in figure 3.*

```
10 REM---------ENERGY EFFICIENCY ANALYSIS---------
20 CLS
30 REM BUILDING SURFACE AREA AND EXISTING INSULATION
40 INPUT "HEATING ZONE (FROM MAP)";N
50 T=N*10
60 INPUT "TOTAL DOUBLE-PANE WINDOW AREA (SQUARE FEET)";GW
70 INPUT "TOTAL SINGLE-PANE WINDOW AREA (SQUARE FEET)";GA
80 INPUT "TOTAL WALL AREA (SQUARE FEET)";WA
90 INPUT "TOTAL ROOF/CEILING AREA (SQUARE FEET)";RA
100 INPUT "TOTAL DOOR AREA (SQUARE FEET)";DA
110 INPUT "R-FACTOR OF EXISTING WALL INSULATION";WR
120 INPUT "R-FACTOR OF EXISTING ROOF/CEILING INSULATION";RR
130 CLS
140 PRINT "------------HEAT LOSS PROFILE------------"
150 PRINT:WL=(1/(WR+2))*WA*T
160 RL=(1/(RR+3))*RA*T
170 GL=(.45*GW*T)+(1.1*GA*T)
180 DL=.54*(.8*(GA+GW)+DA)*T
190 PRINT "LOSS THROUGH WALLS              "INT(WL);"BTU/HR"
200 PRINT "LOSS THROUGH ROOF/CEILING       "INT(RL);"BTU/HR"
210 PRINT "AIR INFILTRATION LOSS           "INT(DL);"BTU/HR"
220 PRINT "LOSS THROUGH WINDOWS            "INT(GL);"BTU/HR"
230 TL=INT(WL+RL+GL+DL)
240 PRINT
250 PRINT "TOTAL HEAT LOSS                 "TL;"BTU/HR"
260 PRINT:PRINT "ENERGY EFFICIENCY IMPROVEMENT PLAN"
270 PRINT
280 PRINT "ADD WALL INSULATION             (ENTER 1)"
290 PRINT "ADD ROOF/CEILING INSULATION (ENTER 2)"
300 PRINT "INSTALL STORM WINDOWS           (ENTER 3)"
310 PRINT "CAULK AND WEATHERSTRIP          (ENTER 4)"
320 INPUT E
330 IF E<3 THEN GOTO 370
340 IF E=3 THEN GL=(.45*(GA+GW)*T)
350 IF E=4 THEN DL=.18*(.8*(GA+GW)+DA)*T
360 GOTO 400
370 INPUT "ADDED R-FACTOR OF NEW INSULATION";R
380 IF E=1 THEN WL=(1/(WR+2+R))*WA*T
390 IF E=2 THEN RL=(1/(RR+3+R))*RA*T
400 CLS:PRINT"----------HEAT LOSS PROFILE WITH PLAN----------"
410 PRINT
420 PRINT "LOSS THROUGH WALL           "INT(WL);"BTU/HR"
430 PRINT "LOSS THROUGH ROOF/CEILING "INT(RL);"BTU/HR"
440 PRINT "LOSS THROUGH WINDOWS        "INT(GL);"BTU/HR"
450 PRINT "AIR INFILTRATION LOSS       "INT(DL);"BTU/HR"
460 PRINT:TN=INT(WL+RL+GL+DL)
470 PRINT "TOTAL HEAT LOSS             "TN;"BTU/HR"
480 PRINT
490 PRINT "HEAT LOSS REDUCTION  "INT(((TL TN)/TL)*100);"%"
500 PRINT:INPUT "TOTAL ANNUAL HEATING COST";H
510 PRINT
520 PRINT "ANNUAL HEATING COST SAVINGS=$":INT(H*(TL-TN)/TL)
530 PRINT "DO YOU WANT TO CHECK THE EFFICIENCY OF OTHER"
540 INPUT "IMPROVEMENTS ? (ENTER 1 IF YES - 2 IF NO)";X
550 IF X=1 THEN CLS:GOTO 260
560 IF X=2 THEN CLS
570 PRINT "DO YOU WANT TO RUN THIS PROGRAM FOR ANOTHER"
580 INPUT "BUILDING ? (ENTER 1 IF YES - 2 IF NO)";Y
590 IF Y=1 THEN GOTO 20 ELSE CLS
600 PRINT "ENERGY AUDIT PROGRAM TERMINATED"
999 END
```

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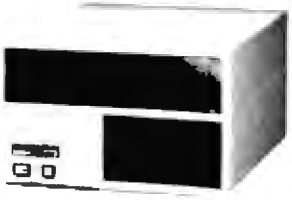
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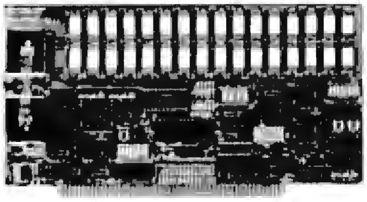


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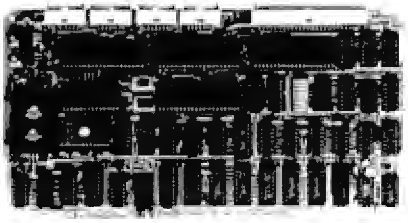
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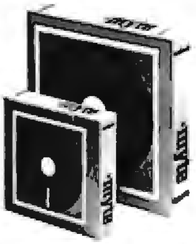
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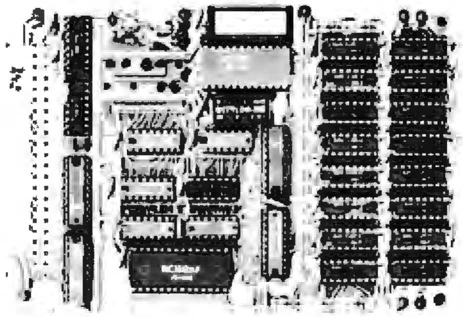
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PROGRAM OPERATION

Computer Display	Sample House Data from Worksheet	Comments
HEATING ZONE (FROM MAP)	4	find your heating zone from figure 2
TOTAL DOUBLE-PANE WINDOW AREA (SQUARE FEET)	132	using the worksheet,
TOTAL SINGLE-PANE WINDOW AREA (SQUARE FEET)	66	find the area of all exposed surfaces
TOTAL WALL AREA (SQUARE FEET)	3002	"
TOTAL ROOF/CEILING AREA (SQUARE FEET)	1500	"
TOTAL DOOR AREA (SQUARE FEET)	42	"
R-FACTOR OF EXISTING WALL INSULATION	9	measure the existing insulation thickness
R-FACTOR OF EXISTING ROOF/CEILING INSULATION	20	and find the R-factor from table 1
Heat Loss Profile Displayed		(see figure 3a)
ENERGY-EFFICIENCY IMPROVEMENT PLAN		
ADD WALL INSULATION		(enter 1)
ADD ROOF/CEILING INSULATION		(enter 2)
INSTALL STORM WINDOWS		(enter 3)
CAULK AND WEATHER STRIP		(enter 4)
	1	choose plan 1, 2, 3, or 4
ADDED R-FACTOR OF NEW INSULATION	9	find R-factor of insulation to be added from tabe 1
Heat Loss Profile with Plan Displayed		(see figure 3b)
Percent Heat Loss Reduction Displayed		(see figure 3b)
TOTAL ANNUAL HEATING COST	900	add last year's heating bills—total annual cost
Annual Savings in Heating Cost Displayed		(see figure 3b)

Figure 4: *An annotated representation of the information requested by the program in listing 1. Data for the sample house is given.*

the existing insulation cannot be exactly determined either. Also, dampness and uneven thickness will alter the heat-transfer properties of insulation.

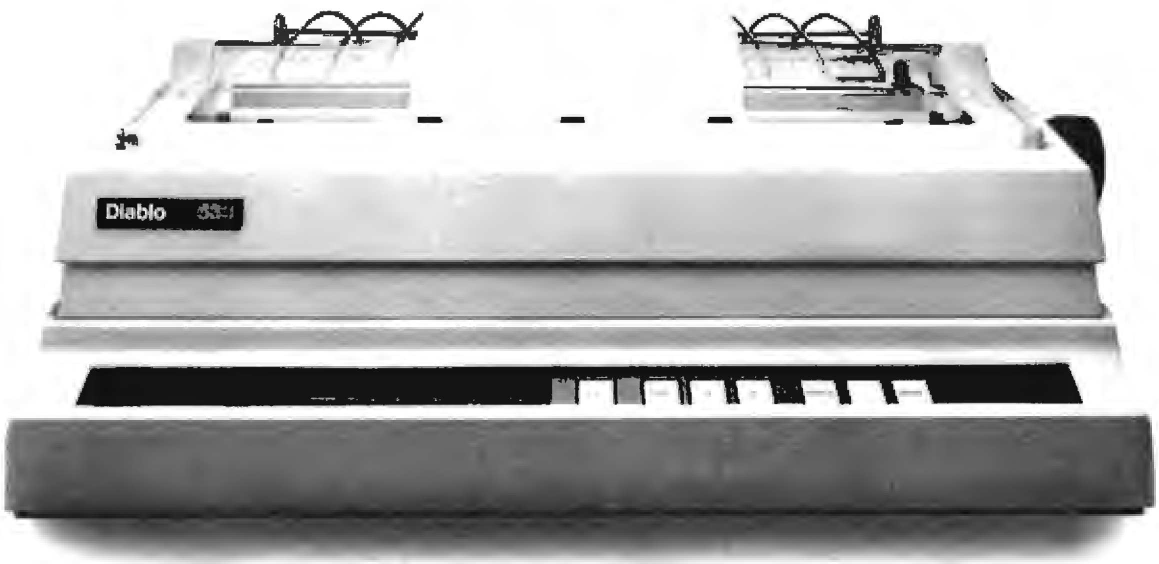
In short, some assumptions are necessary in this program to express the heat-loss characteristics of the home. For most houses, however, the evaluation provided in this program is reasonably accurate for selecting the best heating energy-conservation plan and determining the approximate saving in heating costs.■

Several publications are available from the US government to aid in conserving home heating energy. Among them are:

Building Science #64
Retrofitting Existing Housing for Energy Conservation
Making the Most of Your Energy Dollars

These and other publications can be obtained by contacting the US Department of Commerce, National Bureau of Standards, Washington DC 20230. Your local power utility company and your home heating fuel supplier may also be able to provide you with literature.

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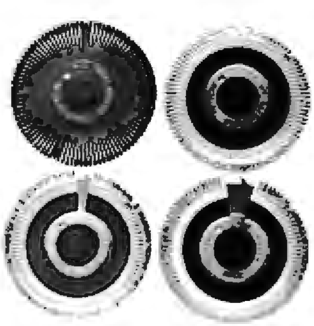


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Bridging the 10-Percent Gap

Paul T Brady
91 Marcshire Dr
Middletown NJ 07748

In my spare time, I'm the administrator of a nature center in Middletown, New Jersey. We have a staff of five, an annual budget approaching $40,000, a mailing list of 1500 names, annual attendance of 10,000 visitors, and a need to type and/or mimeograph letters, handouts, and other literature. (If you wonder how we can support five people on $40,000, we can't; some staff members are on the payroll of other agencies.)

And if you were wondering what a nature center has to do with computers, take a minute to think about the figures in the first paragraph. You'll soon see that we were absolutely hurting for a small computer.

This article describes our problems and eventual success in computerizing many of the office functions at the nature center. It's one of many similar stories, I'm sure. But there are also many small businesses like ours, including grocery stores, museums, law offices, and other firms, that could benefit from computers—but won't because of the 10-percent gap.

The 10-Percent Gap

I make two claims:

1. There is already available a wide range of excellent hardware at reasonable prices that can perform the functions a small business requires.
2. There is also an enormous range of available software that will *almost* do the required job. It will do a 90-percent job. But to bridge the 10-percent gap requires experience and efforts far beyond the abilities or interests of the typical small-business owner. This 10-percent software gap is holding back a virtual explosion of data processing into small businesses.

Background

My computer work began in 1958, programming the TX-0 computer at MIT in machine language (what else). I have sampled many other computers and languages, generally using minicomputers and microcomputers. By profession, I work at Bell Labs and specialize in performance measurements of mid-size systems, especially VAX/VMS systems (made by Digital Equipment Corporation). I also spent many years designing and testing human-factor interfaces to computer systems.

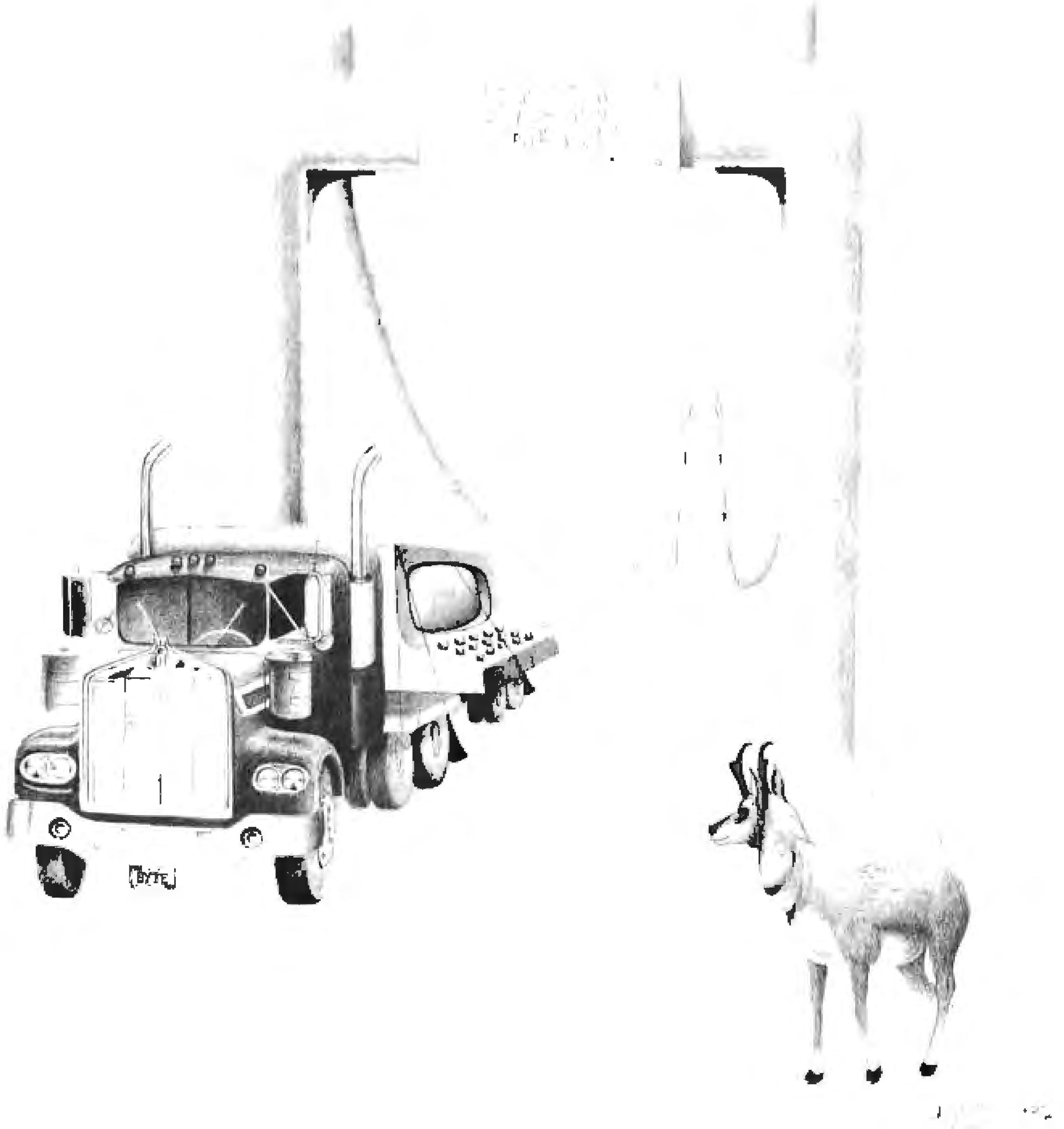
The nature center grew from a citizens' movement in 1969 to save land for a park. We succeeded, and now have a fine 250-acre park with historic buildings and a new nature center. The name of the park is Poricy Park (an Indian name from the 1600s). It is operated by a citizens' committee with an excellent professional staff—who have absolutely no background in computers.

We Needed Help!

The first warning that we needed data processing came from our inability to manage our mailing list by hand. Just try hand-addressing 1000 envelopes! So I wrote a program to print labels from a name-and-address file and put it on a timeshared system. For many years, this program got occasional use whenever we had a mailing.

But there were problems. The computer system was often down for modifications, especially in the evening hours when we usually used it. It was not available to our staff, we had no dial-up equipment, and we often wouldn't have daytime access even if we could dial in. But the most serious problem was that I was the only person in the world who knew how to use the system. If anything happened to me, good-bye mailing list. We finally realized that we had to become self-sufficient, and that several people had to be able to manage the list.

The second need for a computer was realized soon after we opened the park year-round. Our accounting system, managed in part by nonexpert secretaries and in part by volunteers, was a real headache. We often met at nights, pounding on an adding machine generating yards of tape, trying to find minor errors in entering checks or locating missing deposit entries. The annual tax-return time was a nightmare, when we usually had to plow through everything again.



Searching for a Solution

In early 1979, we came up with partial specifications. We had to fit the mailing list on one floppy disk; this demanded either 8-inch disks or 5-inch quad-density disks. We needed an impact printer with adjustable tractor feed (for labels), and, if possible, of letter quality for secretarial work. Finally, we needed a video terminal; we did not care whether it was separate or incorporated into the *main* computer. We had no need for video graphics or color, so we could use any standard terminal.

We began by visiting a computer store, a nicely decorated operation with impressive-looking equipment. We were greeted by a friendly salesperson who asked what we wanted. After we explained who we were and what we needed, he immediately told us they had the solution. This so-called solution was a $15,000 system with bells and whistles, a dot-matrix printer, etc, far out of our price range and probably not even suitable. After finally getting down to a system we might be able to handle, we engaged in dialogue such as:

Clerk: "Suppose you wanted to play chess."
Us: "We don't want to play chess."
Clerk: "But suppose you do."
Us: "We don't. We want to do accounting and mailing-list management."

A little more of this and we got to see the manager. We asked if the BASIC system, or any other system that came with the machine, had decimal floating-point arithmetic, as

opposed to binary floating-point. (Binary floating-point can have round-off error on fractions, intolerable in accounting. Until recently, most microcomputer systems represented numbers only in integer or binary floating-point format.) The manager answered that their systems had great precision, certainly enough for dollars and cents. We explained that we were not talking about *precision*, the number of digits supported, but the way decimal fractions were stored internally. The manager got angry and condescending; we got disgusted. No sale.

The next few months produced similar encounters. All dealers claimed to have just what we wanted, except that they never bothered to ask us what we wanted to do with it, or anything at all about our business. This is one of the fundamental problems of dealers. Because they spend so much time talking to computer freaks, they assume everybody wants to play with systems, languages, and various gadgets. We don't. *Our business is running a nature center—not a computer center.*

Because dealers spend so much time talking to computer freaks, they assume everybody wants to play with systems and languages.

What Causes the Gap?

What causes the gap between software technology and business applications? One reason commonly cited is computer scientists' preference to develop new theories and explore abstract concepts, rather than develop application techniques.

This is illustrated by the "Letters" column in the December 1980 BYTE. There is a letter about a language that will generate a program that will reproduce itself. There's another about stack problems. There's a whole section of comments on the FORTH articles in the August issue. There's even someone who wants to hear more about SNOBOL. (Now there's an oldie!) It's clear there are some pretty sophisticated readers out there.

In my profession as a computer-systems analyst, I often interview computer-science graduates. It is a common lament among interviewers that all we get are people who (1) want to design a new compiler, or (2) want to build an operating system. They are taught the mathematical beauty of stack-oriented languages, or list processors, and so on, and would be right at home with those who wrote the letters to BYTE.

I am certain there's a place for pure programming in our society, but I think the real prizes will go to whoever can make computers understandable and useful to businesses.

The Twain Must Meet

The first part of the solution is to give people the necessary background. Train them in night school, and train their children in grade school. Don't train them how to build self-reproducing programs (unless they really want that), but train them in business applications of computers.

It may be possible to establish a science of computer applications. It is certainly a challenge to write a new language or operating system, but it is also a challenge to develop a discipline that studies applications. How many computer-science graduates know the elements of accounting? How many have studied business administration? These people are very bright, and if they are exposed to the practical problems businesses encounter, they may discover that applications is itself a challenging problem.

We need better standards of commercial software. I am convinced that a common language is hopeless; BASIC comes as close as any, but computer scientists get ill when it is mentioned. (I can empty a room by stating: "BASIC is my language, and GOTO is my favorite instruction." Mentioning COBOL also produces some pretty neat reactions.) Perhaps we cannot settle on a standard language, but at least it should be one that is widely accepted.

Software should be easy to modify or expand. Maybe I am old-fashioned, but I prefer to get source code; it would have saved me hours with our North Star system. At least, tables of transfer vectors and interface hooks should be documented.

Perhaps what we will eventually come to is an industry, already being established, of businesses that specialize in installing software for other businesses. It may be similar to the auto-service industry. I have no idea how to fix a car, yet I buy one with some confidence that my local mechanic (who I happen to think is pretty good) can take care of whatever happens. The analogy is far from perfect, but perhaps it helps make the point.

Our System

Eventually, from the wide range of equipment and operating systems available, we arrived at our current configuration. It includes:

- a North Star Horizon computer with 48 K bytes of memory and two quad-density disk drives (each disk has 360,000 bytes)
- a Perkin-Elmer Bantam terminal
- a beautifully reconditioned Perkin-Elmer Carousel printing terminal, donated by the Perkin-Elmer Corporation (whose computer division is in the town adjacent to the park; clearly a special case for them to do this)

Some of the equipment was purchased with special private grants. No membership funds were used. I emphasize this because we have not, unfortunately, reached the point where contributors think positively about using their donations for a computer. Typewriter, yes; computer, no. Let's hope this attitude soon changes.

We are very pleased with the equipment, but many other manufacturers would do as well. There is much fine hardware on the market.

The main problems occur in the software. There's plenty of software—but virtually none of it bridges the 10-percent gap.

Why Software Is Inadequate

Here are some reasons why commercially available software was unsuitable for our business:

1. It is too complex. I purchased the manual for an accounting program,



Photo 1: *The nature-center computer system consists of a Perkin-Elmer Bantam terminal, a Perkin-Elmer Carousel printer, and a North Star Horizon computer.*

but decided it was overkill for our small business. Many files were manipulated, 5-digit account numbers were used, and fairly elaborate forms were produced. All these were way beyond our needs or ability to handle. In another example, most word-processing systems are fine for professional secretaries or typists, but they have a bewildering array of features. In one popular text editor, virtually every key on the keyboard assumes a special escape role in editing. You can insert, search, delete, search and delete, reformat, and on and on.

2. Much of it is too expensive. We are a small, nonprofit corporation; we barely managed the funds required for the hardware. We simply cannot spend hundreds or thousands more on software.

3. The programs are incompatible with each other. The key used for correcting errors is BACKSPACE in one program, DELETE in another; in one program, you specify line range 2 through 35 as "2,35" and in another, as "2:35"; the letter "s" stands for "save file" in one program, "w" is used to "write" (save) in another. Our staff would never be able to keep these straight. Some vendors are overcoming this problem by offering complete packages. This is a step in the right direction.

4. The commercial software is nearly impossible to modify. Much of it is shipped as machine-language modules. I have years of bit-picking (or bit-twiddling) behind me, and I still find no beauty in deciphering a memory dump. Or the program is in Pascal, or C, or whatever, and we don't have a compiler for that language.

5. Many programs require disk changes and other potentially dangerous procedures to run them. If professional system managers sometimes get disks mixed up, what about nature-center employees?

6. The most important reason of all: the programs don't do what we require. Thus, even if we received a package of compatible programs, all with the same human-factor interface, we would still have to make many modifications to suit our needs. I'll illustrate this with two examples: the salary program and the mailing-list manager.

A Salary Package

A salary program is very useful. Employees work odd hours. Some are paid weekly, some hourly. Deduction status for an employee might change during the year. Part-time workers come and go. Income tax W-2 forms have to be prepared every year. It's nice to automate this.

An advertisement offers a "powerful, flexible payroll program. Federal, state, Social Security, etc, withholdings are automatic." But we have some local obstacles.

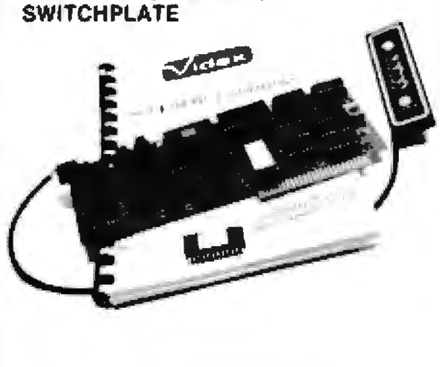
New Jersey has an unemployment and disability tax that affects only the first $7500 of income on a per-person basis. This threshold is crossed at different times by different employees. Mary Smith's year-to-date wages last week were $7404; this week they were $7581. We have to recognize that $7500 was crossed, and tax only the proper fraction of the week's pay. The $7500 figure changes as state policy changes. Does the "powerful, flexible payroll program" handle this tax? [*Various other states have exceptional procedures that create prob-*

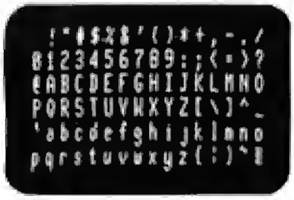
The Text Solution for APPLE II®

Now APPLE II® Owners Can Solve Text Problems With VIDEOTERM 80 Column by 24 Line Video Display Utilizing 7 X 9 Dot Character Matrix

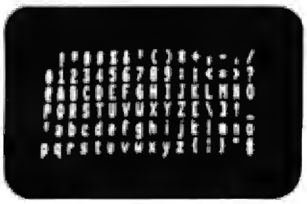
Perhaps the most annoying shortcoming of the Apple II* is its limitation of displaying only 40 columns by 24 lines of text, all in uppercase. At last, Apple II* owners have a reliable, trouble-free answer to their text display problem. VIDEOTERM generates a full 80 columns by 24 lines of text, in upper and lower case. Twice the number of characters as the standard Apple II* display. And by utilizing a 7 by 9 character matrix, lower case letters have true descenders. But this is only the start.

VIDEOTERM, MANUAL, SWITCHPLATE





7X12 MATRIX
18X80 OPTIONAL



7X9 MATRIX
24X80 STANDARD

VIDEOTERM

BASICs — VIDEOTERM lists BASIC programs, both Integer and Applesoft, using the entire 80 columns Without splitting keywords Full editing capabilities are offered using the ESCape key sequences for cursor movement With provision for stop/start text scrolling utilizing the standard Control-S entry. And simultaneous on-screen display of text being printed.

Pascal — Installation of VIDEOTERM in slot 3 provides Pascal immediate control of the display since Pascal recognizes the board as a standard video display terminal and treats it as such. No changes are needed to Pascal's MISC.INFO or GOTOXY files, although customization directions are provided. All cursor control characters are identical to standard Pascal defaults

Other Boards — The new Microsoft Softcard* is supported So is the popular D. C. Hayes Micromodem II* , utilizing customized PROM firmware available from VIDEX The powerful EasyWriter* Professional Word Processing System and other word processors are now compatible with VIDEOTERM. Or use the Mountain Hardware ROMWriter* (or other PROM programmer) to generate your own custom character sets. Naturally, VIDEOTERM conforms to all Apple OEM guidelines, assurance that you will have no conflicts with current or future Apple II* expansion boards.

Advanced Hardware Design — VIDEOTERM's on-board asynchronous crystal clock ensures flicker-free character display. Only the size of the Pascal Language card. VIDEOTERM utilizes CMOS and low power consumption ICs, ensuring cool, reliable operation All ICs are fully socketed for easy maintenance Add to that 2K of on-board RAM, 50 or 60 Hz operation, and provision of power and input connectors for a light pen. Problems are designed out, not in

Available Options — The entire display may be altered to inverse video, displaying black characters on a white field PROMs containing alternate character sets and graphic symbols are available from Videx A switchplate option allows you to use the same video monitor for either the VIDEOTERM or the standard Apple II* display, instantly changing displays by flipping a single toggle switch The switchplate assembly inserts into one of the rear cut-outs in the Apple II* case so that the toggle switch is readily accessible And the Videx KEYBOARD ENHANCER can be installed, allowing upper and lower case character entry directly from your Apple II* keyboard

Firmware — 1K of on board ROM firmware controls all operation of the VIDEOTERM. No machine language patches are needed for normal VIDEOTERM use

Firmware Version 2.0

Characters	7 x 9 matrix	Display	24 x 80 (full descenders)
Options	7 x 12 matrix option; Alternate user definable character set option, Inverse video option		18 x 80 (7 x 12 matrix with full descenders)

Want to know more? Contact your local Apple dealer today for a demonstration. VIDEOTERM is available through your local dealer or direct from Videx in Corvallis, Oregon. Or send for the VIDEOTERM Owners Reference Manual and deduct the amount if you decide to purchase. Upgrade your Apple II* to full terminal capabilities for half the cost of a terminal VIDEOTERM, At last

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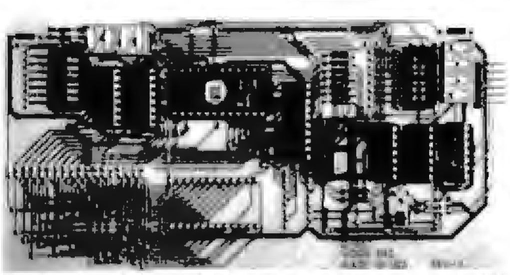
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• PUT THE SHIFT AND SHIFT LOCK BACK WHERE IT BELONGS
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• ACCESS ALL YOUR KEYBOARD ASCII CHARACTERS

Videx has the perfect companion for your word processor software the **KEYBOARD AND DISPLAY ENHANCER** Install the enhancer in your APPLE II and be typing in lower case just like a typewriter If you want an upper case character, use the SHIFT key or the CTRL key for shift lock Not only that, but you see upper and lower case on the screen as you type Perfectly compatible with Apple Writer and other word processors like, for example, Super-Text

If you want to program in BASIC, just put it back into the alpha lock mode, and you have the original keyboard back with a few improvements Now you can enter those elusive 9 characters directly from the keyboard, or require the Control key to be pressed with the RESET to prevent accidental resets

KEYBOARD AND DISPLAY ENHANCER is recommended for use with all revisions of the APPLE II It includes 6 ICs, and EPROM and dip-switches mounted on a PC board, and a jumper cable Easy installation meaning no soldering or cutting traces Alternate default modes are dip-switch selectable You can even remap the keyboard, selecting an alternate character set, for custom applications



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lems for general-purpose payroll programs....RSS]

The workmen's-compensation audit usually requires salary to be accounted between arbitrary dates, such as February 1 to August 20. Can the package handle that?

No matter what package is offered, we will find *something* we need that is not included.

The Mailing-List Manager

Many mailing-list managers are offered. They usually contain various fixed fields, a few including special *keying* fields. Surely we could use one of these.

Probably not. We had eight years' experience with our first mailing-list program and developed a long wish list for the next one. We don't handle just names and addresses. We handle memberships. We want to record contributions and remarks. If Jack Armstrong donated an enlarger for the darkroom, we want to record that. We might want a list of all people who have contributed since last September. Or all those who contributed last year, but not this year. Or everyone who gave more than $50. New contributions have to be easy to enter, and an automatic purge should be done on very old contributions to keep the file size reasonable. Key fields should allow "ORing" categories, such as "volunteers or patrons." The program must print labels, give statistical analyses of contribution records, and have internal checks on zip code validity.

If such a program is marketed, we didn't find it. And these requirements are not at all unusual—they are what any business such as ours would reasonably require.

Software Development

In the fall of 1979, uncertain how much software we could purchase and what it would do for us, we received our North Star computer. It came with BASIC, DOS (the North Star disk operating system), and a few memory utilities such as disk copy, hexadecimal or ASCII dump, etc. There was no machine-language assembler or disassembler (symbolic dump), nor was there a text editor.

Since we had no funds for such software, I began playing with BASIC and found that I liked it very much. Best of all, it allowed direct access to memory with FILL and EXAM (POKE and PEEK) and raw keyboard input of characters, essential for picking up special control keys.

We ended up coding all of our software ourselves. Each program was first outlined and discussed with other computer people and the nature-center staff. Each took a few weeks to write and document. By summer 1980, we had the following programs:

- a text editor
- a program to record field trips we ran, with attendance, date, etc, and an analysis feature to yield summary statistics over any time span for all types of trips
- a payroll program
- a general-accounting package, with a wide range of features, has already saved untold hours of volunteer and staff time

- a label program, which handles any number of files, and prints names, addresses, and optional comments in list or label form, is used for special mailing lists, such as the list of volunteers
- a main mailing-list program that, as already mentioned, also keeps track of contributions

Operating-System Changes

The 10-percent gap exists not only for commercial-application programs, but also for languages and operating systems. The North Star software comes with several pages of documentation on how to make changes to suit your hardware or other special requirements. These were useful, but the beginning programmer might have difficulty understanding the functions of these changes. However, some changes we had to make were not documented, as in the following example.

After writing the text editor and getting it to work with the video terminal, I tried it with the printer. It started off all right, but carriage returns suddenly began to be inserted at seemingly random places in the text. This made the editor unusable, so I had to find what was causing the returns and suppress them.

The problem turned out to be in the operating system. I fixed it in an afternoon with hardware boots, hexadecimal object-code dumps, and some trial and error. It's the kind of thing that turns on a computer buff, but not the manager of a nature center.

Computer 1, Staff 0

When the editor and a few other programs were completed, it was time to introduce the computer to the staff. It was a rather difficult first month. But to judge from my experience with human factors and computers, it was no different from any other first encounter of inexperienced people with computers.

The initial problems were severe but were quickly cured. The worst one involved the inability of people to differentiate which program and which mode they were working in. People would give BASIC commands to the operating system (such as "RUN") and receive puzzling responses (in this case, "?"). When they finally got into a program I wrote, I expanded on the error messages, but they ignored them anyway. The most common error in the editor was typing text when commands were expected (ignoring the command prompter) and vice versa (ignoring a text prompter). Training and much practice overcame this.

But the most persistent problem, which still exists to a small degree, is getting people to grasp the concept of *files*. Assume the editor is used to create a file "turtle." The next day, our secretary enters the editor and reads the file "turtle." She modifies it and, instead of writing it back to "turtle," writes it instead to "shell."

Any experienced user of systems like these will realize there are now two files on the disk: "turtle" and "shell." But not the novice. The novice thinks the editor somehow worked on the file "turtle" and refiled it under "shell." In other words, our secretary views the system as a filing cabinet in which a folder was taken out, worked on, and put somewhere else.

The confusion was compounded when "turtle" was read in, "shell" was read in and *appended* to "turtle," and the result was written to either of the old files or even a new one, "egg." The problem arises because a novice doesn't realize the computer actually works on a special memory or temporary file. The novice insists that the computer is working on "turtle" or "shell " and will not accept the concept of working on this merged file that really has no name and no direct correspondence to any file on the disk.

Some computer-oriented friends suggested an interesting scheme to explain the file concept. We obtained several decks of playing cards and had everyone stand around a table holding five or six cards. I sat at the table playing the role of the computer. Each player's hand was a file, with the name of the player. We began with file "barbara." Instead of putting her cards on the table, I copied them, dealing myself an identical hand from another deck. I then

modified my hand (the computer-memory file), all the while pointing out that nothing was happening to her hand. I then copied the new file back to her hand, changing it. Or I copied it to someone else's hand. We concatenated hands, wrote them to different files, and did a variety of things that simulated what computers do.

It worked! This exercise went a long way in clearing up the confusion, and I heartily recommend it to others. But don't let drop-in visitors get the wrong idea about what you're doing with the cards!

A Happy Ending

A few months after our staff's first encounter with the computer, things had settled into a steady state, and the staff was using it productively. At that point, one of the principal users, a secretary, left to help her husband in a small business. (No, they don't have a computer—yet.) The new secretary arrived, and I fully expected to have to start all over with training.

I was wrong. I spent almost no time at all. Instead, *the other staff members trained her*. How's that for a self-reproducing system?

Some of you might think that a happy ending to this story would be to say that our system continues to grow, we are finding more and more uses for the system, hope to expand to a Winchester-technology hard-disk drive, recode everything in ... (Wow, did I almost open Pandora's box!), and look toward a national network for nature-center data communications.

Perhaps some of these things will occur. But in the meantime, we are quite content with the system. I have stopped coding, except for minor improvements, and can now spend my time outdoors finding wild flowers and mushrooms. The staff treats the computer as a piece of standard office equipment, and they welcome the time it has saved them. As our director put it, "We once thought it was an unnecessary complication, and now we depend on it." She might have added, "And we take it for granted." What happier ending could this story have? ■

Discover the Machine Beneath the Machine
A ZX80 Monitor Program

R Scott FitzGerald, 570 NW Walnut, Corvallis OR 97330

The most powerful instructions of Sinclair Research's ZX80 BASIC interpreter are PEEK, POKE, and USR. These instructions allow access to the machine beneath the machine by letting you examine, modify, and execute the ZX80's natural language: Z80 machine code.

The Z80 instruction set has all the functions of the 8080 set, plus some extremely powerful commands of its own: block transfers, extensive bit manipulation and testing, indexed and displaced addressing, relative jumps, and programmed I/O (input/output). Besides the 8080 registers, the Z80 has a duplicate register bank and two index registers, an interrupt-vector register, and a dynamic-memory-refresh register. This adds up to a power-packed microprocessor "under the hood" of your ZX80.

So why bother programming in BASIC when Z80 machine language is only a POKE away? One reason may be that the tedium of entering an endless string of POKE statements to run a machine-language program discourages you from venturing outside BASIC.

In this "System Note," I present a monitor program, written in ZX80 BASIC, that gives you the power to examine and modify memory using octal notation and to execute Z80 machine-language programs. The program MONITOR is designed to run on a ZX80 system with a minimum of 1 K bytes of programmable memory and a 4 K-byte interpreter. After you enter MONITOR in a 1 K-byte system, you will still have enough memory left for a machine-language program more than 150 bytes long.

Listing 1 shows the program MONITOR. When run, MONITOR displays:

OCTAL MONITOR

and the prompt MODE? on the video screen. You then have three choices. You can:

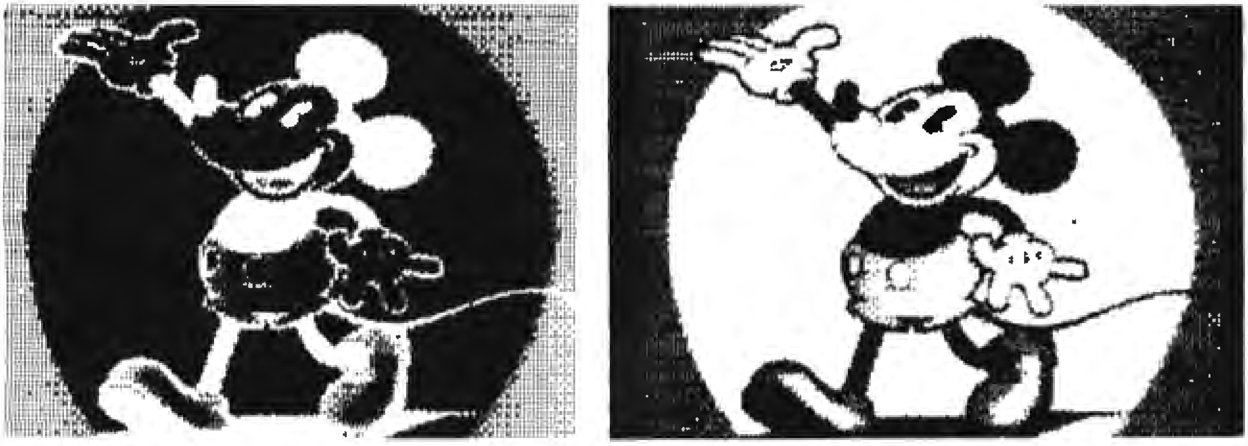
- enter a 1, which will cause a branch to the EXECUTE routine
- enter a 2, which will result in a branch to the EXAMINE/MODIFY routine
- enter a 3, which will result in an exit from MONITOR to the BASIC interpreter

The program uses octal numbers for data input and output because this is the natural number base for use with the Z80 op codes.

Here are MONITOR's modes explained in greater detail:

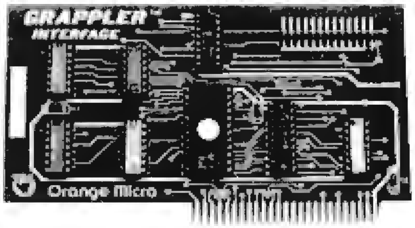
- Mode 1: EXECUTE. A 1 response to the MODE? prompt permits execution of the machine-language routine you have loaded into memory. Execution will begin at the decimal address specified in response to the START ADDR?(DEC) prompt. The machine-code routine should end with a RET (return) instruction (octal 311) to let the monitor regain control; otherwise, you'll literally have to pull the plug to return the computer to your control. Pulling the plug will erase MONITOR and your machine-code program as well.

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*Requires Graftrax-80

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MARGINS	— Set left and right margins
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• Mode 2: EXAMINE/MODIFY. In mode 2, you can examine and modify locations in memory, starting at the address you specify after the START ADDR?(DEC) prompt. This routine displays the address and its contents in octal and waits for your input. If you input an octal number from 000 to 377, it will replace the previous contents of that location (assuming that you are not addressing read-only memory). If you enter a −1, the routine will go on to the next byte in memory without modifying anything. Any number outside the −1 to 377 range will terminate the EXAMINE/MODIFY routine and display the MODE? prompt again.

• Mode 3: EXIT. Entering 3 in response to the MODE? prompt lets you exit the monitor, and control returns to the ZX80 BASIC interpreter's text-input module. Don't exit MONITOR, however, if you want to keep a valid copy of your machine-language program in memory. Because the ZX80 BASIC interpreter uses a great deal of memory to display MONITOR, the display file will probably overrun your machine-language program.

The ability to execute Z80 machine-language programs on the ZX80 opens a new dimension to the serious ZX80 programmer. I hope that the program MONITOR will give you easier access to some of the powerful features of your ZX80. ■

Listing 1: *A machine-language monitor for the Sinclair ZX80. This program lets you examine and modify sequential memory locations and execute machine-language programs stored in memory.*

```
10 CLS
20 PRINT "OCTAL MONITOR"
30 PRINT "MODE?"
40 INPUT M
50 IF (M<1) OR (M>3) THEN GO TO 10
60 CLS
70 GO TO 400*M
400 PRINT "EXEC"
410 GO SUB 2000
420 PRINT "HL=";USR(S)
430 GO TO 20
800 PRINT "EXAM/MOD"
810 GO SUB 2000
820 LET C=0
830 LET D=S
840 LET N=4
850 GO SUB 3000
860 LET D=PEEK(S)
870 LET N=2
880 GO SUB 3000
890 PRINT ":=";
900 INPUT D
910 PRINT D
920 IF (D<-1) OR (D>377) THEN GO TO 10
930 IF D=-1 THEN GO TO 960
940 GO SUB 4000
950 POKE S,A
960 LET S=S+1
970 LET C=C+1
980 IF C-16*(C/16)=0 THEN CLS
990 GO TO 830
1200 STOP
2000 PRINT "START ADDR?(DEC)";
2010 INPUT S
2020 PRINT S
2030 RETURN
3000 FOR K=0 TO N
3010 LET Q=D/(8**(N-K))
3020 LET D=D-Q*(8**(N-K))
3030 PRINT CHR$(Q+28);
3040 NEXT K
3050 PRINT " ";
3060 RETURN
4000 LET A=0
4010 FOR K=0 TO 2
4020 LET Q=D/(10**(2-K))
4030 LET D=D-Q*(10**(2-K))
4040 LET A=A+Q*(8**(2-K))
4050 NEXT K
4060 RETURN
```

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Graphics Fundamentals

Kathleen Bresnahan Sandifur
624 Six Flags Dr #130
Arlington TX 76011

To make effective use of any graphics system, you must first understand the functions universal to all such systems. For the neophyte, the only readily available method for mastering graphics concepts is to attack a dissertation of incomprehensible detail—an endeavor that can be as frustrating as reading the fine print on your insurance policy.

In this article I try to put some graphics concepts into perspective. Four subroutines of the Hewlett-Packard Graphics/1000 software package are singled out: WINDW, LIMIT, VIEWP, and SETAR. The terms are peculiar to the software package, but the concepts are universal to all graphics. As a vehicle for conveying these concepts, the application program LOGO is presented in this article.

The LOGO program incorporates the four subroutines mentioned above to allow easy manipulation of size, shape, and positioning of a logo. By following the implementation of the four subroutines and the explanation of results related to parameter changes, the uninitiated reader can gain an easy grasp of the graphics function.

The underlying objective of all graphics systems is to capture an image, manipulate it and then project it to another location or surface. The image must first be presented to the graphics system. For the purpose of the sample program, the image was presented by sketching a logo on a sheet of graph paper, approximating this sketch with straight line segments, and tabulating the coordinates for the end points of these segments (see figure 1). The coordinates were calculated by arbitrarily setting x and y axes to correspond to the horizontal and vertical lines of the

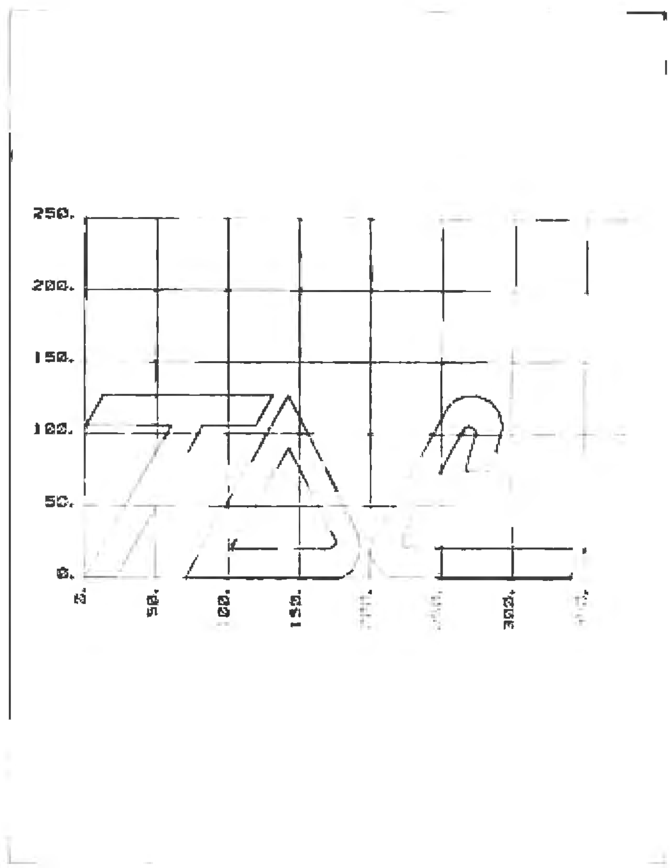


Figure 1: *Sketch of the logo letters on graph paper establishing x and y coordinates for the line segments that make up the letters.*

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graph paper. This process is a form of *digitization* and is only one of the many methods available. All have the objective of conveying information in a form recognizable to the graphics system. Coordinates representing the logo are entered at lines 33 to 101 of the sample program (see listing 1). Once the image is made available to the system, the process of capturing the image, manipulating it, and projecting it involves four steps:

- Determine the boundaries surrounding the image to be captured (WINDW).
- Set the limits of the device to the boundaries of the paper or transparency to be used (LIMIT).
- Determine the boundaries within which the image is to be projected on the paper or transparency (VIEWP).
- If you don't want the projected image distorted, then the window surrounding the image and the viewport on the projecting surface must both have the same width/height ratio (SETAR).

WINDW

When the graphics system receives the digitized representation of the image, it needs a frame of reference to designate where the image to be captured is located. To generate this reference frame or *window*, the WINDW subroutine is invoked. The general form of WINDW is:

```
CALL WINDW(IGCB,X1,X2,Y1,Y2)
```

where (X1,Y1) designates the lower-left corner of the rectangular window and (X2,Y2) designates the upper-right corner. Because this rectangle is to frame the image or a portion of the image represented in the digitization process, the parameters for the WINDW subroutine must be generated from the same axes, units, and origin used in the digitization process (the ones established on the graph paper).

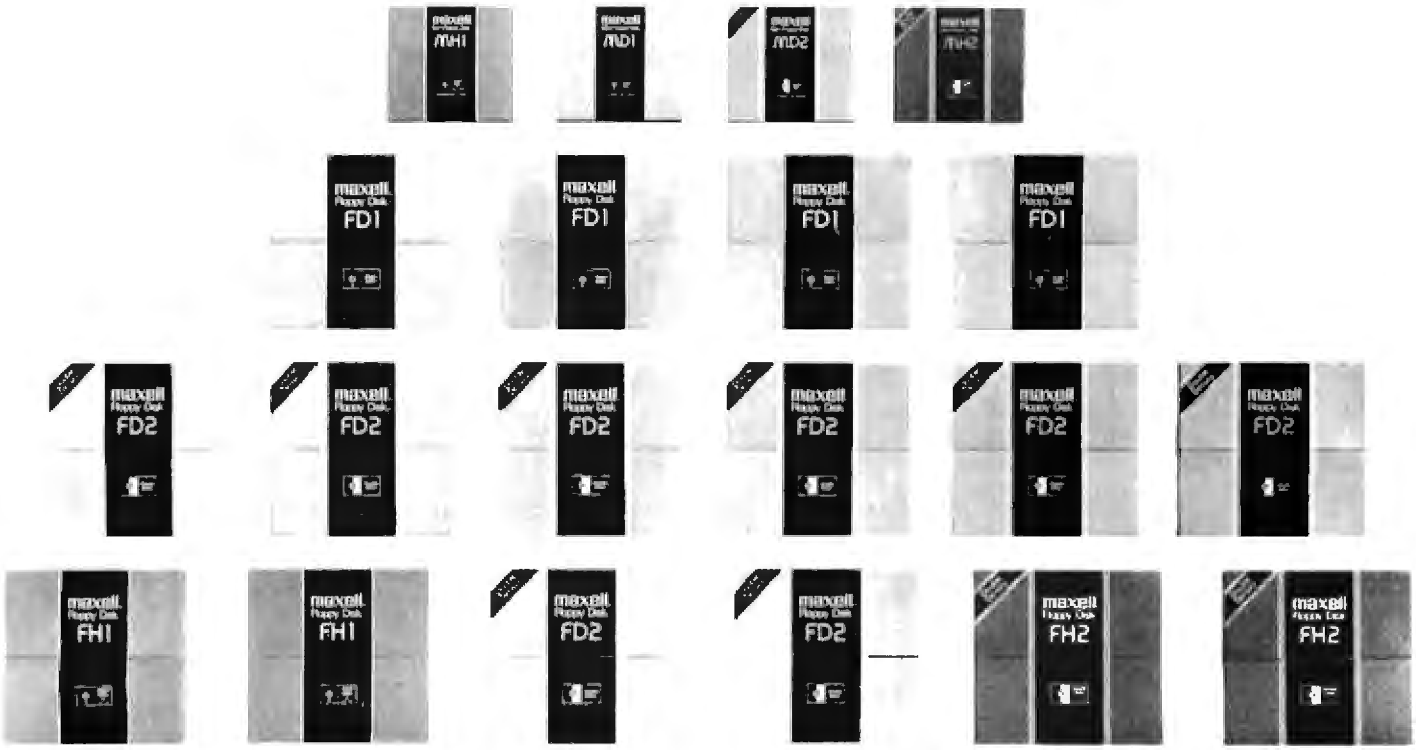
The setting of the WINDW parameters in line 29 of the sample program to:

```
CALL WINDW(IGCB,0.,355.,0.,130.)
```

specifies that the lower-left corner of the rectangular window is zero units in the *x* direction and zero units in the *y* direction (at the *origin* on the graph paper). Also, the upper-right corner of the window is at 355 units in the *x* direction and 130 units in the *y* direction (to the far right and middle of the graph paper). Since the window encompasses the entire logo "TDC," the captured image for graphics manipulation will be the entire logo. If, however, the window had been specified by:

```
CALL WINDW(IGCB,200.,355.,0.,130.)
```

then the window would frame only the "C" portion of the logo, and only that image would be available for graphics manipulation.



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Listing 1: *LOGO, the program used to produce figures in this article. The program is written to run on a Hewlett-Packard Graphics/1000 system.*

```
&111A  T=00004 IS ON CR00023 USING 00018 BLKS R=0000

FTN4,L
         PROGRAM LOGO
C
C        THIS PROGRAM DRAWS A LOGO "TDC"       (KATHLEEN SANDIFUR 10-79)
C
         DIMENSION IGCB(192),IBUF(10),XLUT(5),V(4),W(4),G(2),XL(4)
         EQUIVALENCE (LU,IBUF),(ID,IBUF(10))
C
C        ESTABLISH ID AND LOGICAL UNIT FOR PLOTTER
C
         LUT=LOGLU(I)
         WRITE(LUT,01)
     01  FORMAT("ENTER LU, ID:_")
         READ(LUT,*) LU,ID
C
C        INITIALIZE PLOTTER & SELECT PEN
C
         CALL PLOTR(IGCB,ID,1,LU)
         CALL PEN(IGCB,2)
C
C        ****************************************************************
C        *  REFERENCES IN ARTICLE TO LIMIT, SETAR, VIEWP, WINDOW        *
C        *              REFER TO THE FOLLOWING CALLS                    *
C        ****************************************************************
C
         CALL LIMIT(IGCB,XL(1),XL(2),XL(3),XL(4))
         CALL SETAR(IGCB,AR)
         CALL VIEWP(IGCB,V(1),V(2),V(3),V(4))
         CALL WINDOW(IGCB,W(1),W(2),W(3),W(4))
C
C        ********* DRAW "T" ************************
C
         CALL MOVE(IGCB,22.,0.)
         CALL DRAW(IGCB,82.,105.)
         CALL DRAW(IGCB,119.,105.)
         CALL DRAW(IGCB,131.,126.)
         CALL DRAW(IGCB,12.,126.)
         CALL DRAW(IGCB,0.,105.)
         CALL DRAW(IGCB,60.,105.)
         CALL DRAW(IGCB,0.,0.)
         CALL DRAW(IGCB,22.,0.)
C
C        ********* DRAW "D" ************************
C
         CALL MOVE(IGCB,70.,0.)
         CALL DRAW(IGCB,178.,0.)
         CALL DRAW(IGCB,185.,3.)
         CALL DRAW(IGCB,190.,8.)
         CALL DRAW(IGCB,193.,15.)
         CALL DRAW(IGCB,194.,20.)
         CALL DRAW(IGCB,193.,25.)
         CALL DRAW(IGCB,192.,30.)
         CALL DRAW(IGCB,190.,34.)
         CALL DRAW(IGCB,142.,126.)
         CALL DRAW(IGCB,70.,0.)
C
C        ********* INNER "D"  START LEFT BOTTOM ****
C
```

Listing 1 continued on page 290

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0060          CALL DRAW(IGCB,142.,90.)
0061          CALL DRAW(IGCB,175.,27.)
0062          CALL DRAW(IGCB,176.,25.)
0063          CALL DRAW(IGCB,175.,23.)
0064          CALL DRAW(IGCB,173.,21.)
0065          CALL DRAW(IGCB,170.,20.)
0066          CALL DRAW(IGCB,102.,20.)
0067    C
0068    C     ********* DRAW "C"  START LEFT BOTTOM ***********
0069    C
0070          CALL MOVE(IGCB,203.,10.)
0071          CALL DRAW(IGCB,202.,13.)
0072          CALL DRAW(IGCB,201.,17.)
0073          CALL DRAW(IGCB,203.,26.)
0074          CALL DRAW(IGCB,255.,118.)
0075          CALL DRAW(IGCB,260.,123.)
0076          CALL DRAW(IGCB,265.,125.)
0077          CALL DRAW(IGCB,270.,126.)
0078          CALL DRAW(IGCB,275.,126.)
0079          CALL DRAW(IGCB,285.,122.)
0080          CALL DRAW(IGCB,291.,115.)
0081          CALL DRAW(IGCB,294.,105.)
0082          CALL DRAW(IGCB,290.,90.)
0083          CALL DRAW(IGCB,285.,74.)
0084    C
0085    C     ********* INNER "C"  START LEFT UPPER *****
0086    C
0087          CALL DRAW(IGCB,267.,74.)
0088          CALL DRAW(IGCB,275.,100.)
0089          CALL DRAW(IGCB,274.,103.)
0090          CALL DRAW(IGCB,272.,104.)
0091          CALL DRAW(IGCB,270.,105.)
0092          CALL DRAW(IGCB,267.,104.)
0093          CALL DRAW(IGCB,224.,29.)
0094          CALL DRAW(IGCB,223.,25.)
0095          CALL DRAW(IGCB,224.,23.)
0096          CALL DRAW(IGCB,225.,21.)
0097          CALL DRAW(IGCB,351.,20.)
0098          CALL DRAW(IGCB,340.,0.)
0099          CALL DRAW(IGCB,215.,1.)
0100          CALL DRAW(IGCB,210.,3.)
0101          CALL DRAW(IGCB,203.,10.)
0102    C
0103     9999 CALL PEN(IGCB,0)
0104          CALL PLOTR(IGCB,ID,0)
0105          STOP
0106          END
```

LIMIT

The LIMIT subroutine defines the view surface on the device—in other words, the surface within which all graphics must occur. After deciding on the size of the paper or transparency desired, the width and height dimensions are used to delimit the view surface via the LIMIT subroutine. The general form of LIMIT is:

CALL LIMIT(IGCB,X1,X2,Y1,Y2)

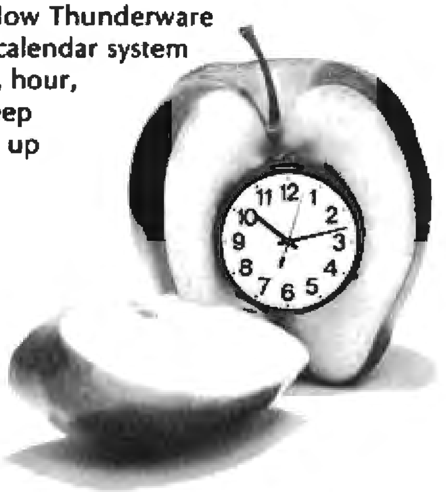
with the *x* and *y* units specified in millimeters. As a result, all graphics must now occur within an area bounded in the horizontal direction from X1 mm to X2 mm, and in the vertical direction from Y1 mm to Y2 mm, with the origin corresponding to the lower-left corner of the device view surface.

In the sample program, a logo is to be projected to a 15-inch by 10-inch sheet of paper (380 mm by 250 mm). Line 26 of the program would incorporate these dimensions as LIMIT parameters as follows:

CALL LIMIT(IGCB,0.,380.,0.,250.)

To further illustrate the use of the LIMIT subroutine, if

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you want to confine graphics to an 8½-inch by 11-inch (215 mm by 280 mm) area, set LIMIT parameters as follows:

CALL LIMIT(IGCB,0.,215.,0.,280.)

VIEWP

Within the view surface set by LIMIT, the image can be restricted to a desired area. In other words, the logo can be spread across the entire paper or transparency, or confined to only a small area. A *viewport* designates a rectangular portion of the view surface to which the image in the window is to be mapped. The VIEWP subroutine defines the positioning of the viewport, and its general form is:

CALL VIEWP(IGCB,X1,X2,Y1,Y2)

where (X1,Y1) designates the lower-left corner of the viewport and (X2,Y2) designates the upper-right corner. The x and y axes correspond to the lower edge and the left edge, respectively, of the LIMIT-designated view surface.

The units for x and y vary according to the *aspect ratio*, or the ratio of the width to the height of the view surface. If the aspect ratio, abbreviated AR, is greater than 1, the horizontal length of the view surface corresponds to 100 × AR units, and the vertical length corresponds to 100 units. If AR is less than 1, the vertical length corresponds to 100/AR units and the horizontal length to 100 units. When CALL LIMIT is not initiated, the view surface defaults to the limit of the device, which for the HP 9872A has an AR of 1.52. Therefore, to position a viewport to cover the upper-right quadrant of the view surface, specify VIEWP as follows:

CALL VIEWP(IGCB,76.,152.,50.,100.)

The entry of the viewport parameters in the sample program occurs at line 28.

SETAR

At this point in the graphics explanation, the process can be visualized as taking a snapshot and projecting the captured image onto a screen. Everything within the rectangular window is mapped through the rectangular viewport for positioning on the viewing surface, which itself has been delimited via the LIMIT subroutine.

If the rectangular window and the rectangular viewport have the same shape (if the aspect ratio is the same), the image can be transferred *point for point* without distorting any geometric figures. The relative size of images will change, but a circle will remain a circle, and angles between intersecting lines will not change. If the aspect ratio of the window is not the same as that of the viewport, then the image projected on the view surface will be distorted: a circle will become an ellipse, and the angle between intersecting lines will change. To alleviate

this problem when coverage of the largest possible portion of the selected view surface is desired, the subroutine SETAR (set viewport aspect ratio) is used. The general form for SETAR is:

CALL SETAR(IGCB,AR)

To implement SETAR, calculate the AR for the window. The AR for the window encompassing the entire logo is 2.73 (355/130 = 2.73). This value is incorporated at line 27 of the sample program as follows:

CALL SETAR(IGCB,2.73)

As a result, instead of a point-for-point mapping of the image in the window to the viewport, the mapping is now from the window to a reconfigured viewport which has the aspect ratio selected by SETAR.

This new viewport is shrunk in size so that it just fits inside the old viewport while maintaining an AR corresponding to the window. After shrinking the new viewport to fit inside the old viewport, one dimension of the old viewport will have unused area. The new viewport is centered along this dimension. The image in the window, therefore, will be mapped undistorted to an area within the originally specified viewport, centered along one dimension and totally filling the other dimension. This provides the largest undistorted projection of the image onto the delimited view surface without requiring undue calculation for viewport positioning.

Parameter Changes

A brief and simplified explanation of each of the four subroutines has now been presented and the location of their implementation in the LOGO program specified. The following will document how individual changes in the subroutine parameters correlate to output changes from the program.

1. *Set window to encompass the logo; and default LIMIT, SETAR, and VIEWP parameters.*

CALL WINDW(IGCB,0.,355.,0.,130.)

The resulting output is a recognizable, although distorted, projection of the logo covering the total viewing surface (see figure 2). The projection covers the total viewing surface because of the default mode for LIMIT and VIEWP. Because CALL LIMIT was not initiated, the viewing surface defaults to the physical limits of the device. For the HP9872A, this is equivalent to the following at line 26:

CALL LIMIT(IGCB,0.,380.,0.,250.)

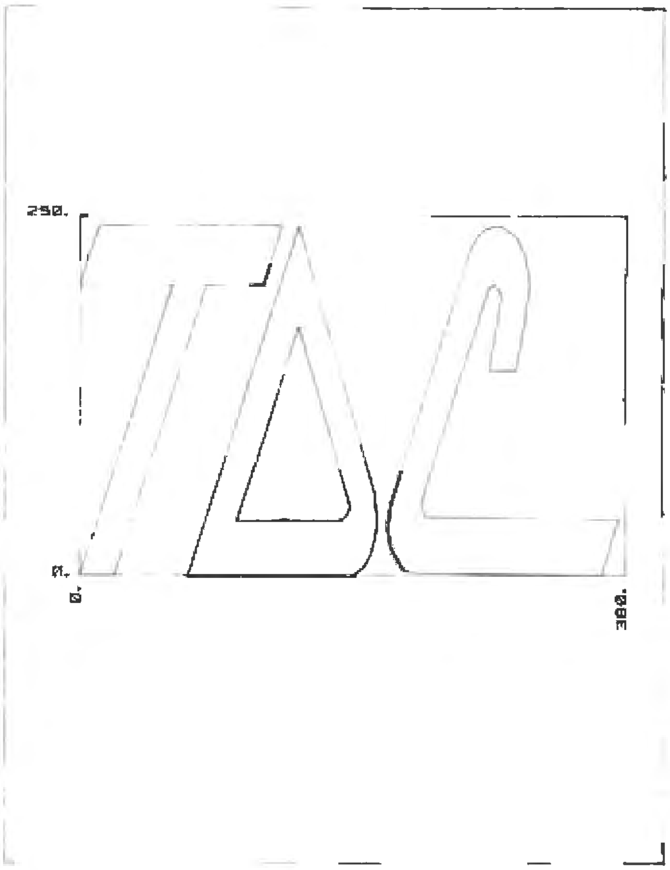


Figure 2: *The logo translated to fill the entire graph area. Note the geometric distortion of the letters, which results because the aspect ratio (width/height ratio) of the window and viewport are not equal.*

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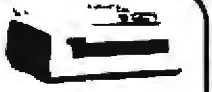
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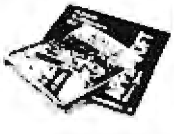
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For the projection to cover the entire viewing surface, the viewport must cover the physical limits of the device. This happens by default since a CALL VIEWP was not executed. For the HP9872A, this is equivalent to entering the following at line 28:

```
CALL VIEWP(IGCB,0.,152.,0.,100.)
```

The entire logo is projected because the window chosen was of the appropriate size and used units corresponding to the units in which the coordinates of the linear segment approximation were entered.

The resulting output is slightly distorted because the AR for the window and the viewport differ. The viewport AR defaulted to 1.52 (380 mm wide by 250 mm high), and the AR for the window is 355/130, or approximately 2.73.

2. Set window to encompass the logo; set viewport aspect ratio to correspond to window aspect ratio (SETAR); and default LIMIT and VIEWP parameters.

```
CALL WINDW(IGCB,0.,355.,0.,130.)
CALL SETAR(IGCB,2.73)
```

The resulting output is an undistorted projection of the logo centered in the vertical direction and covering the total viewing surface in the horizontal direction (see figure 3). The entire logo was projected because the window was determined the same way as in the previous example.

The projection was centered in the vertical direction and covered the total horizontal view surface because of the viewport reconfiguration that occurs when the SETAR routine is implemented. With SETAR set to 2.73, the reconfigured viewport corresponds to a rectangle with an AR of 2.73 being shrunk until it just fits within the old viewport. When a rectangle with a 2.73 AR is shrunk to fit within a rectangle with a 1.52 AR, the horizontal dimension will be totally filled and the vertical dimension will have unused space.

As prescribed by the SETAR routine, the reconfigured viewport will be centered in the vertical direction and totally cover the horizontal view surface. When the image within the window is mapped to this reconfigured viewport, it will project an image covering the horizontal direction and centered in the vertical direction. The resulting image is undistorted because the AR of the viewport was designated as 2.73 by SETAR, and the aspect ratio for the window was also 2.73.

3. Set window to encompass the logo; set viewport aspect ratio to correspond to window apsect ratio (SETAR); set the physical view surface (LIMIT) to correspond to an 8½-inch by 11-inch viewgraph; default VIEWP parameters.

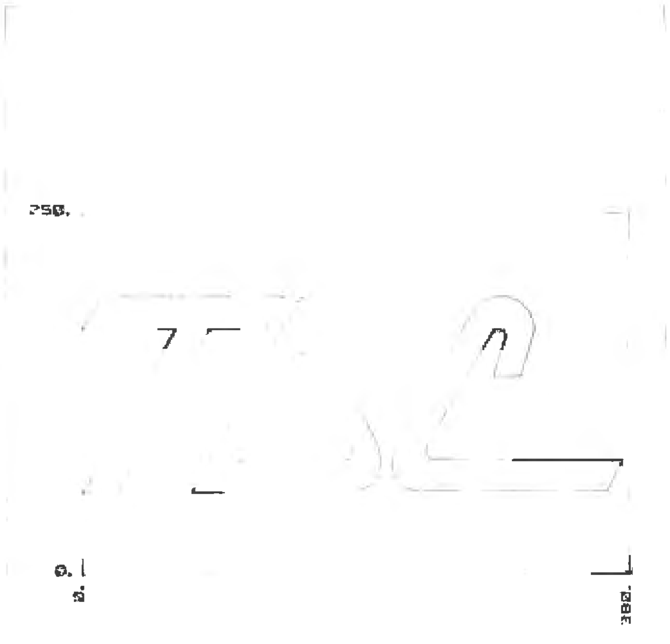


Figure 3: *An undistorted projection of the logo vertically centered and covering the total viewing surface in the horizontal direction. Window aspect ratio is equal to viewport aspect ratio.*



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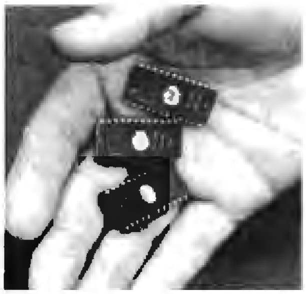
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```
CALL LIMIT(IGCB,0.,215.,0.,280.)
CALL SETAR(IGCB,2.73)
CALL WINDW(IGCB,0.,355.,0.,130.)
```

The resulting output is an undistorted projection of the logo centered in the vertical direction and covering the width of a viewgraph (see figure 4). The restriction of the projection to an 8½-inch by 11-inch area located at the lower left of the device results from setting LIMIT. VIEWP is still defaulted to LIMIT, and the other parameters are the same as for the previous example. As the viewport is shrunk down to fit within LIMIT, it will fill the viewgraph in the horizontal direction and be centered in the vertical direction.

4. Set window to encompass logo; set physical view surface (LIMIT) to correspond to an 8½-inch by 11-inch viewgraph; set viewport to five different locations (line 28); default SETAR.

```
CALL LIMIT(IGCB,0.,215.,0.,280.)
CALL WINDW(IGCB,0.,355.,0.,130.)              AR = 2.73
CALL VIEWP(IGCB,6.,40.,6.,18.5)       (Lower left AR = 2.73)
CALL VIEWP(IGCB,40.,94.,6.,25.8)     (Lower right AR = 2.73)
CALL VIEWP(IGCB,6.,70.,100.5,124.)   (Upper right AR = 2.73)
CALL VIEWP(IGCB,70.,94.,116.2,124.)   (Upper left AR = 2.73)
CALL VIEWP(IGCB,20.,80.,25.8,100.5)       (Center AR = 0.79)
```

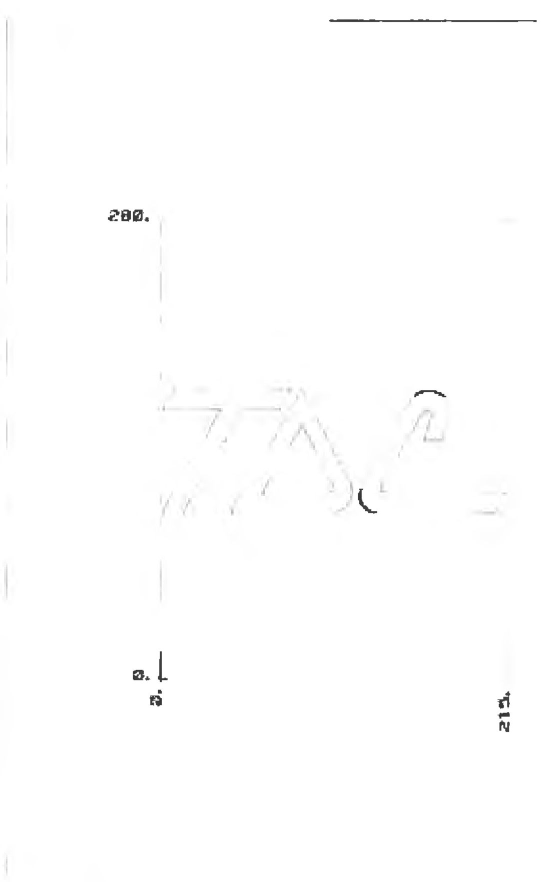


Figure 4: *The viewing surface changed to 8½ inches by 11 inches (215 mm by 280 mm). The logo is undistorted, centered in the vertical direction, and expanded to cover the entire viewing surface in the horizontal direction.*

The resulting output is five projections of the logo within the 8½-inch by 11-inch area. The four corner projections are of various sizes, all undistorted. The center projection is distorted from that of the original sketch (see figure 5).

To understand the significance of the VIEWP parameters entered, the consequence of defaulting the SETAR subroutine must be considered. Not calling SETAR defaults the viewport to the area delimited by LIMIT (the 215-mm by 280-mm viewgraph area). Because the viewport is a rectangle corresponding to the viewgraph area, it has an AR of 0.768 (215/280 = 0.768). For the purpose of determining the vertical parameters for viewport positioning, therefore, the height of the viewgraph corresponds to 131 units. (Referring to the explanation of VIEWP: if AR is less than 1, then the vertical view surface is 100/AR units, or in this case 100/.768 = 131 units).

In like manner, the width of the viewgraph corresponds to 100 units. (If AR is less than 1, the horizontal length corresponds to 100 units.) It is of little consequence to calculate parameters for positioning desired viewports. But if undistorted projections are desired, the viewports must be defined with an AR equal to that of the window (2.73). Subsequently, the corner viewports (calculated with an AR of 2.73) generate undistorted projections, while the center viewport calculated with an aspect ratio of 0.79 generates a distorted projection.

Summary

This article is not designed to make you a graphics expert. You still may not know a logical view surface from an illogical one, and normalized device coordinates may not strike you as normal at all. But your perspective on the graphics process should now be broad enough to let you tackle more detailed technical explanations without losing sight of the basics. ■

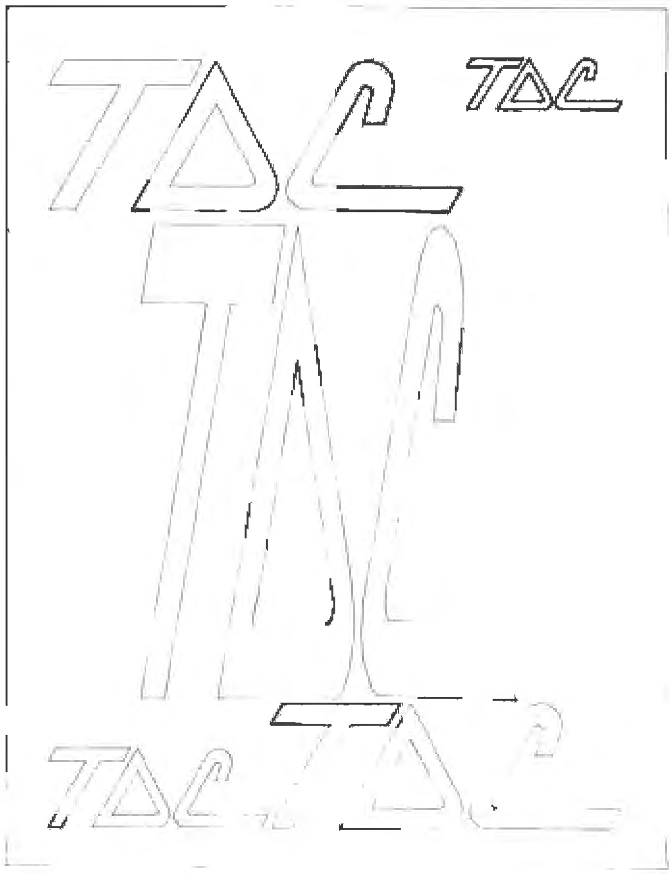


Figure 5: *Confined to an 8½-inch by 11-inch (215 mm by 280 mm) viewing surface, the logo has been projected in 5 different locations and sizes. The 4 corner locations appear undistorted (the aspect ratios of the viewport and the window are the same), while the central figure is distorted (aspect ratios of viewport and window are unequal).*





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PET

Adventure at Pearl Harbor, a submarine battle game for the Commodore PET. Cassette, $19.95. United Software of America, 750 Third Ave, New York NY 10017.

Piano Player, a music-generation program for the Commodore PET. Cassette, $14.95. United Software of America (see address above).

Space Intruders, a graphics arcade game for the Commodore PET. Cassette, $29.95. United Software of America (see address above).

Super Gomoku, a game that simulates checkers for the PET. Cassette, $9.95. United Software of America (see address above).

TRS-80

Balloon Bust, a circus game for the TRS-80 Model I Level II. Cassette, $15.95. Programma International, 3400 Wilshire Blvd, Los Angeles CA 90010.

Blockade, graphics arcade game for the TRS-80 Color Computer. Cassette, $10; source list, $5. Bank Software, 37 Balmoral Dr, Spring Valley NY 10977.

Breakout, graphics arcade game for the TRS-80 Color Computer. Cassette, $10; source listing, $5. Bank Software (see address above).

Runaway Racer, a car-racing simulation game for the TRS-80 Model I Level II. Cassette, $15.95. Programma International (see address above).

Space Colony, an arcade game for the TRS-80 Model I Level II. Cassette, $15.95. Programma International (see address above).

Scrip-Fix, a patch for the Scripsit word-processing system for the TRS-80 Model I. Cassette, $9.95. Programma International (see address above).

Space Intruders, an arcade game for the TRS-80 Model I and III. Floppy disk, $19.95. Adventure International, POB 3435, Longwood FL 32750.

Starship, graphics arcade game for the TRS-80 Color Computer. Cassette, $10; source listing, $5. Bank Software (see address above).

Super Gomoku, a game that simulates checkers for the TRS-80. Cassette, $9.95. United Software of America, 750 Third Ave, New York NY 10017.

ZX80

A Night in Las Vegas, a Las Vegas gambling simulator for the Sinclair ZX80. Cassette, $9.95. Lem Laboratories, POB 2382, La Jolla CA 92038.

ZX80 Double Breakout, a graphics arcade game for the Sinclair ZX80. Cassette, $14.95. Softsync Inc, POB 480, Murray Hill Sta, New York NY 10156.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Ten reasons why your floppy disk should be a BASF FlexyDisk.®



More than four decades of experience in magnetic media—BASF invented magnetic recording tape, the forerunner of today's wide range of magnetic media, back in 1934, and was the first independent manufacturer of IBM-compatible floppy disks.

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100% certification—every single disk is tested at thresholds 2-3 times higher than system requirements, to be 100% error-free.

For the name of your nearest supplier, write BASF Systems, Crosby Drive, Bedford, MA 01730, or call 617-271-4030.

BASF

Floppy Disks Mag Cards Cassettes Computer Tapes Disk Packs Computer Peripherals

Books Received

Active Filter Design Handbook, G S Moschytz and Petr Horn. New York: John Wiley & Sons, 1981; 17.5 by 25 cm, 316 pages, hardcover, ISBN 0-471-27850-5, $45.

The Ada Programming Language, I C Pyle. Englewood Cliffs NJ: Prentice-Hall, 1981; 17.5 by 23.5 cm, 293 pages, softcover, ISBN 0-13-003921-7, $14.95.

BASIC for Students: With Applications, Michael Trombetta. Reading MA: Addison-Wesley, 1981; 16 by 23.5 cm, 291 pages, softcover, ISBN 0-201-07611-X, $9.95.

Build Program Technique: A Practical Approach for the Development of Automatic Software Generation Systems, John G Rice. New York: John Wiley & Sons, 1981; 15.5 by 23.5 cm, 372 pages, hardcover, ISBN 0-471-05278-7, $29.95.

CDS/ISIS and MINISIS: A Functional Analysis and Comparison, Robert L Valantin. New York: UNIPUB, POB 433, Murray Hill Sta, 1981; 17.5 by 25 cm, 88 pages, softcover, ISBN 0-88936-296-3, $6.50.

Computer Acronyms, Abbreviations, Etc, Claude P Wrathall. Princeton NJ: Petrocelli Books, 1981; 15 by 22 cm, 486 pages, hardcover, ISBN 089433-138-8, $17.50. Also available in softcover for $14.

Cryptography, A Primer, Alan G Konheim. New York: John Wiley & Sons, 1981; 16.5 by 24 cm, 432 pages, hardcover, ISBN 0-471-08132-9, $34.95.

Digital Counter Handbook, Louis E Frenzel Jr. Indianapolis IN: Howard W Sams & Company, 1981; 13.5 by 22 cm, 264 pages, softcover, ISBN 0-672-21758-9, $10.95.

Early British Computers, Simon Lavington. Bedford MA: Digital Press, 1980; 15 by 21 cm, 140 pages, softcover, ISBN 0-932376-08-8, $8.

Educational Software Directory, Apple II Edition, Sterling Swift Publishing Company. Manchaca TX: Sterling Swift Publishing, 1981; 15 by 22 cm, 103 pages, softcover, ISBN 0-88408-141-9, $11.95.

From ENIAC to UNIVAC, An Appraisal of the Eckert-Mauchly Computers, Nancy Stern. Bedford MA: Digital Press, 1981; 19 by 24 cm, 286 pages, hardcover, ISBN 0-932376-14-2, $21.

Fundamental Concepts of Information Modeling, Matt Flavin. New York: Yourdon Press, 1981; 15 by 23 cm, 128 pages, softcover, ISBN 0-917072-22-7, $10.

How to Design & Build Your Own Custom Robot, David L Heiserman. Blue Ridge Summit PA: Tab Books, 1981; 13 by 21 cm, 462 pages, softcover, ISBN 0-8306-1341-2, $12.95; hardcover, ISBN 0-8306-9629-6, $18.95.

How to Plan, Design and Implement a Bad System, Ronald B Smith. Princeton NJ: Petrocelli Books Inc, 1981; 14 by 22 cm, 157 pages, hardcover, ISBN 0-89433-148-5, $14.

Introduction to Computer Organization, Ivan Tomek. Rockville MD: Computer Science Press, 1981; 16 by 23.5 cm, 456 pages, hardcover, ISBN 0-914894-08-0, $21.95.

Linear Integrated Circuits, Practice and Applications, Sol D Prensky and Arthur H Seidman. Reston VA: Reston Publishing Company, 1981; 16 by 23.5 cm, 354 pages, hardcover, ISBN 0-8359-4084-5, $21.95.

Microcomputer Architecture and Programming, John F Wakerly. New York: John Wiley & Sons, 1981; 17 by 23.5 cm, 692 pages, hardcover, ISBN 0-471-05232-9, $27.95.

The Microelectronics Revolution, edited by Tom Forester. Cambridge MA: MIT Press, 1981; 15.5 by 23.5 cm, 589 pages, softcover, ISBN 0-262-56021-6, $12.50; hardcover, ISBN 0-262-06075-2, $25.

The Minicomputer in On-Line Systems, Small Computers in Terminal-Based Systems and Distributed Processing Networks, Martin Healy and David Hebditch. Cambridge MA: Winthrop Publishers, 1981; 18.5 by 24 cm, 334 pages, hardcover, ISBN 0-87626-579-4, $22.95.

Osborne CP/M User Guide, Thom Hogan. Berkeley CA: Osborne/McGraw-Hill, 1981; 19 by 23.5 cm, 283 pages, softcover, ISBN 0-931988-44-6, $12.99.

Pascal Programming for the Apple, T G Lewis. Reston VA: Reston Publishing, 1981; 15.5 by 23 cm, 234 pages, softcover, ISBN 0-8359-5454-4, $12.95.

A Primer on Pascal, Second Edition, Richard Conway, David Gries, and E Carl Zimmerman. Cambridge MA: Winthrop Publishers, 1981; 18.5 by 24.5 cm, 430 pages, hardcover, ISBN 0-87626-675-8, $17.95; softcover, ISBN 0-87626- 671-5, $12.95.

The Programming Language Landscape, Henry Ledgard and Michael Marcotty. Chicago IL: Science Research Associates, 1981; 16.5 by 24.5 cm, 460 pages, hardcover, ISBN 0-574-21340-6, $22.95.

Robot Intelligence with Experiments, David L Heiserman. Blue Ridge Summit PA: Tab Books, 1981; 13 by 21 cm, 322 pages, softcover ISBN 0-8306-1191-6, $9.95; hardcover, ISBN 0-8306-9685-7, $16.95.

Software Design: Methods and Techniques, Lawrence J Peters. New York: Yourdon Press, 1981; 17.5 by 25.5 cm, 248 pages, softcover, ISBN 0-917072-19-7, $23.

Structured Programming in FORTRAN, Louis A Hill Jr. Englewood Cliffs NJ: Prentice-Hall, 1981; 17.5 by 23.5 cm, 526 pages, softcover, ISBN 0-13-854612-6, $15.95.

Take Aim: Volume I, James Hoyt Clark. Beaverton OR: Matrix Publishers, 1981; 388 pages, 22 by 28 cm, softcover, ISBN 0-916460-29-0, $16.95.

Video/Computers, How to Select, Mix, and Operate Personal Computers and Home Video Systems, Charles J Sippl and Fred Dahl. Englewood Cliffs NJ: Prentice-Hall, 1981; 18.5 by 24 cm, 246 pages, softcover, ISBN 0-13-941849-0, $7.95; hardcover, ISBN 0-13-941856-3, $15.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

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BYTELINES

News and Speculation About Personal Computing

Conducted by Sol Libes

Smart Credit Card Uses EEPROM: SGS-ATES has introduced XCARD, an electronic credit card that uses an EEPROM (electrically erasable, programmable read-only memory) to keep track of your remaining credit. The EEPROM is encapsulated in a thin plastic card. It's inserted into a reader that accesses the data in the 17-word by 8-bit EEPROM and subtracts the amount charged by writing to the EEPROM. Fifteen bytes are alterable; the others are for identification and security code (to check for fraudulent erasure). Prototypes are being tested in Italy.

Big-Money Prizes in Computer Chess Battle: Big money is waiting for the computer chess program developer whose program defeats a human chess expert. *Omni* magazine is offering $16,000 to the first program that can beat David Levy, the Scottish National Chess Champion (Elo rating of 2310) (Elo ratings are recognized by the World Chess Federation.) A Netherlands software firm will award $50,000 to the developer of the first program that bests Max Euwe (Elo rating of 2540), and the Fredkin Foundation of Massachusetts will pay $100,000 to the program that overpowers the standing world chess champion (typical Elo rating of 2700).

Most experts feel these prizes could be won within the next five years, and will certainly be awarded within the next ten years. The United States Chess Federation has voted to permit computers to compete in sanctioned matches with human players. In 1983, there will be a team-chess tournament in which one team will be entirely computers.

VOS Gains in Popularity: Switching from one computer to another usually means jumping from one DOS (disk operating system) to another. Then, you have to learn how to operate an entirely new system, which often means redeveloping existing software so that it will run. In a commercial environment, this can be very expensive.

To overcome this problem, researchers at the Lawrence Berkeley Laboratory, University of California–Berkeley, have created a VOS (virtual-operating system) as an interface between the DOS and the hardware. Called Software Tools, the system has already been implemented on several dozen systems ranging from IBM, DEC (Digital Equipment Corporation), Honeywell, and Burroughs mainframes to minicomputers and even microcomputers using Digital Research's CP/M DOS. Using a VOS, an organization's software can outlive its hardware, which does away with costly software redevelopment.

The Software Tools VOS is supported by a user group that publishes a newsletter, directory, documentation, holds regular meetings, and makes the Software Tools software available on magnetic media for $35. For more information contact Debbie Scherrer, Lawrence Berkeley Laboratory, CSAM-50B/3209, University of California, Berkeley CA 94720.

Anglo-French Videotext Standard: British and French negotiators have agreed on a common videotext/teletext standard that makes Britain's Prestel and France's Antiope systems compatible. Canada also may adopt the standard, which could affect American videotext systems.

Robotics Update: Standard & Poor's predicts that robotic sales in this country will leap from less than $100 million to nearly $1 billion by the end of the decade. (As an aside, Japan already uses more than three times as many robots as the US.) General Electric has disclosed that it will replace 15,000 workers with 8000 robots during the next five years; and that if it cannot do this, it will not be able to compete economically.

Industrial robots currently cost in the $7500 to $250,000 range (with one specialized unit selling for $2.5 million). The average price is around $40,000, which is expected to fall to $10,000 by 1983 as companies such as IBM and Texas Instruments are expected to enter the market.

Robots are projected to cost between $1.75 to $4.75 an hour, compared to the $12 to $15 per hour wages paid for skilled labor. Their greatest impact has been in the automobile, steel, and aerospace industries. Dr Richard John, Director of the Office of Energy and Environment, of the Transportation System Center, Cambridge, Massachusetts, has predicted that by 1985 automation will replace more than 200,000 workers in the auto industry.

The Fujitsu Francu robot factory, in Japan, reports that it operates 16 hours a day entirely by robots. Human workers come in for eight hours to complete the final assembly of the machines and robots. Fujitsu feels that it will have the plant completely robotized by 1985. Hitachi claims to have 500 scientists and engineers working on the development of a new generation of robots that will be able to "see, feel, and walk up and down the factory floor supervising other robots."

Microbot Inc of Menlo Park, California, has had its $1700 robotic arm, used with a Radio Shack TRS-80, on the market for over a year. Thus far, 40 have been sold. Terrapin Inc has sold 150 of its Turtles, which can run a maze or draw pictures. But most of these units have gone into schools, not the home.

The problem is that the cost of a robot that will do meaningful tasks is still very high. Although low-cost sensors and mechanical components are available, a huge amount of expensive electronic processing is required. A general-purpose robot requires a multiprocessing, multitasking computer system, with a high degree of artificial intelligence so that the robot can sense its environment and respond properly within a reasonable time. More advances in artificial-intelligence programming techniques are still needed.

Most experts agree that robots will move into the home just as computers have done—but this is still at least five years and maybe as much as 20 years away. We will probably see the first "home robots" performing only specific or limited sets of tasks. Most likely the first applications will be robotic aids for the handicapped. For example, Stanford University has modified an industrial robotic arm for use by quadriplegics. It recognizes voice commands, repeats them for verification, then acts accordingly. Also, it can pick up a telephone, fetch a book, turn pages, pour drinks, or hold a glass. The Veterans Administration is currently testing the unit.

Experimenters interested in building a robot should note that Hobby Robotics Company, POB 997, Lilburn GA 30247, has announced a mobile unit that consists of a body and two arm manipulators. It costs $1495. The user must supply the electronics. Hobby Robotics also publishes a quarterly newsletter.

Heathkit will jump into the robotics market next year with an under-$1000 robot kit. It will be mobile and will have a seven-motor manipulator, sonar-type sensor, a Motorola 6809-based controller, and an "experimenter's area" where users can wire circuits. There will be several modes of operation, including automatic and teach/learn modes. It will be primarily an educational tool, teaching modern industrial-control techniques.

New Scheme To Halt Software Piracy: To cope with software pirates, suppliers have used nonstandard data formats, slashed their prices low, or tried to ignore the problem. Some have printed their documentation in light blue ink to prevent photocopying.

But this resulted in a catch-22: the suppliers who use nonstandard formats have been severely criticized by purchasers who cannot make backup copies and must return the disk to the supplier if it is damaged. This is a real annoyance and, if the supplier charges for this service, engenders resentment. Format-independent programs that copy the disk bit by bit are available by popular demand.

Now, at long last, Micro-Technology Unlimited, Raleigh, North Carolina, and Hal Chamberlin, creator of many innovative microcomputer features, have implemented a previously talked about method for preventing piracy: a software-readable serial number embedded in hardware. Here's how it works: the supplier integrates the code in the software when it is ordered. When the program runs, the two serial numbers are compared; if they do not match, the program doesn't run. Thus, users can make any number of copies and integrate a program with other software to form a new package.

I suspect that the serial number is embedded in a ROM (read-only memory) that uses an algorithm known only to the hardware manufacturer and licensed software vendors. It may use a PLA (programmable-logic array), which cannot be duplicated as simply as a ROM. Also, the software-checking routine has to be done in a clever and subtle way so that it cannot be easily located and bypassed.

Virtual Memory For Microcomputers: Early next year, Intel, Zilog, Motorola, and National Semiconductor will introduce integrated circuits to add VMM (virtual-memory management) to 16-bit microprocessors. This will give systems the large-capacity storage previously found only in large mainframes.

VMM creates a more efficient integration of the primary small (but fast) semiconductor main memory and the secondary (slow) large disk storage. It frees the programmer from worrying about the details of storage allocation. Also, it more efficiently manages the use of memory and disk storage when many users share memory.

Zilog, Motorola, and National Semiconductor also will introduce separate MMU (memory-management unit) integrated circuits to work with their 16-bit microprocessors. Intel will unveil a new version of its 16-bit microprocessor that will include an MMU circuit. The Zilog MMU will manage an 8-megabyte memory space compared to the others' 16-megabytes.

Super-Graphics: Nippon Electric Company (NEC) is about to go into production on a new graphics-controller integrated-circuit chip that will make super-color graphics possible on microcomputers. Listen to these specifications: displays 2048 by 2048 pixels (picture elements) in the black-and-white mode or 1024 by 1024 pixels in the color mode; generates all timing and synchronization signals; allows both graphics and text on the same screen; supports up to 64 K (16-bit word) display memory; contains hardware for drawing lines, arcs, circles, rectangles, and characters at 800 ns per pixel; supports two display areas (independently pannable); has an auto-advance cursor; will display 256 characters per row and up to 100 rows per screen; will zoom display to sixteenfold; has a light-pen input; 8-bit interface for microcomputers; and DMA (direct-memory access) capability . . . all in one 40-pin package. Samples should become available next month with production quantities obtainable early next year. Single-quantity price is expected to be $150.

To Be A 128 K-Bit Or A 256 K-Bit ROM—That Is The Question: Although five integrated-circuit manufacturers are providing samples of the new 128 K-bit, or 16 K-byte, ROM (read-only memory), others have opted to skip the that size and go directly to 256 K bits (32 K bytes), notably Motorola. These large-sized ROMs are expected to be used mostly in high-level language processors, intelligent typewriters, smart terminals, language translators, and speech-synthesis systems. You can expect to see 128 K-bit ROMs on the market by year's end and the 256 K-bit ROMs by mid-1982.

Apple Computer Registers Stock Offering: Apple Computer Inc has registered a proposed public stock offering of 2½ million shares at $27.50 each. (Its original offering last year was 5 million shares at $22 each, although this rose $7 minutes after going on sale.) Also, the president and vice chairman of Apple (A C Markkula and Michael M Scott) have granted the underwriters options to pur-

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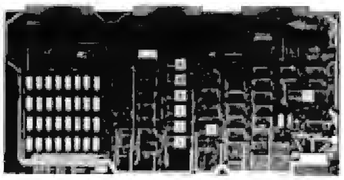
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SPECIFICATION	QUAY 500	HORIZON-2-32K-D
Architecture	**Single Board**	S100 bus
CPU	Z80A, 4MHz.	Same
Dynamic RAM (std)	**64 Kb.**	32 Kb.
Disk drive type	Double density	Same
No. of drives (std/max)	2/4	Same
Capacity per drive (on-line)	**200 Kb.**	180 Kb.
Direct Memory Access (DMA)	**Yes**	No
CP/M* disk operating system	**Standard**	Optional
Unit Price	**$2,995.**	$3,095.

SPECIFICATIONS	QUAY 520	HORIZON-2-32K-Q
Disk drive type	Quad density	Same
Capacity per drive (on-line)	**400 Kb.**	360 Kb.
Unit Price	**$3,495.**	$3,595.

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chase up to 125,000 of their personal shares, reducing Markkula's and Scott's respective holdings to 12.5% and 4.9%. Xerox has pulled back its interest from 720,000 shares to 470,000 shares.

Apple spent $9.1 million on research and development in the first half of 1981, compared with $7.3 million for all of 1980. It also claims to have shipped more than 4000 Apple IIIs by the end of April.

FCC Revises Interference Rules: The Federal Communications Commission (FCC) has revised its rules regarding the certification of small computers for radio-frequency interference (RFI). The revision clarifies the definition for exempt devices: self-contained devices with clock frequencies of 495 kHz or less are now exempt from certification. However, virtually all microcomputers presently sold have higher clock rates and are not exempt.

If your television set is bothered by RFI from your personal computer, citizen's band radio, etc, you may be interested in obtaining a free booklet entitled "How to Identify and Resolve Radio-TV Interference Problems." It is published and distributed by the FCC.

BASIC Standards Manual Published: The Government Printing Office has published a two-volume standard on the BASIC language. The stanadard is based on the ANSI (American National Standards Institute) minimum criteria for the language. The 556-page document describes test programs to check if a BASIC implementation complies with the Federal Information Processing Standard 68 and ANSI standard X3.60-1978.

Volumes 1 and 2 cost $4 and $9.50, respectively. Order them from the Superintendent of Documents, US Government Printing Office, Washington DC 20402. The order numbers are 003-003-02262-4 (Volume 1) and 003-003-02263-2 (Volume 2).

Xerox 820 Personal Computer: Xerox has introduced a desk-top personal computer, called the Xerox 820. It costs $2995. Its original internal code name was WORM, which stood for Wonderful Office Revolutionary Machine.

The Xerox 820 uses the Z80 microprocessor, has 64 K bytes of memory, two single-sided single-density 5-inch floppy-disk drives, and two serial and two parallel ports. A Diablo 630 printer is available for another $2900, and an 8-inch floppy-disk (250 K-byte) drive is $800.

The 820 uses the CP/M operating system (a de facto microcomputer standard), with certain limitations (e.g., CP/M's powerful input/output byte feature is not implemented). But, it is a significant boost for the CP/M-software market. Also, Xerox will offer Microsoft BASIC, CBASIC-II, COBOL-80, and several currently available CP/M-based software packages.

Xerox will furnish its own version of the popular WordStar word-processing software package. Most of its changes are in redefining the Control sequence functions—which undoubtedly will confuse users who are running the package on other systems.

The video display is memory-mapped and shares low-memory space via a bank I/O (input/output) port-select scheme; the disk controller uses the popular 1771 integrated circuit. Reset causes a jump to a ROM (read-only memory) in high memory from which the user must boot CP/M, which does not start automatically. A Zilog SIO (serial I/O) integrated circuit is used to handle I/O operations. Although Xerox implies that the 820 can be used as a workstation in an Ethernet network, no internal Ethernet interface is provided at this time.

On the minus side, the Xerox machine has two Control keys, both positioned adjacent to the space bar (they may be easy to hit accidentally). Also, I wonder why Xerox used drives with only 92 K bytes storage per drive, when virtually everyone else has gone to double-sided or double-density drives with two or four times the storage capacity. Both HP (Hewlett-Packard) and IBM have introduced Z80-based personal computers; DEC (Digital Equipment Corporation) may follow suit. Further, Xerox will have to compete with several dozen machines with equal or better specifications, some of which are less expensive and have been available for as long as three years.

On the plus side, Xerox knows that its name can sell a lot of machines, and it has already signed up several large distribution organizations, such as Computerland. It is interesting to note that Xerox's 17 retail stores have been selling Apple computers. I wonder whether this, too, will continue?

Random News Bits: Apple Computer is offering a free resource guide on using microcomputers as aids for the handicapped. It summarizes work being done in the field and current projects. It includes a bibliography and where to go for help and advice. For a copy of "Personal Computers for the Physically Disabled: A Resource Guide," write to Apple Computer, Resource Guide, Marketing Services Department, 10260 Bandley Dr, Cupertino CA 95014. . . . The *People's Republic* of China will soon conduct its first national census. The US Commerce Department has sent the Chinese a computer and some US Census Bureau experts to help. The last census was done using the abacus . . . CompuServe Inc, one of the largest time-sharing systems for home-computer users, claims to have 10,000 customers, concentrated mostly around New York City, the eastern seaboard, the Silicon Valley area, and Los Angeles. . . . Attendance at last April's San Francisco Computer Faire rose to almost 32,000. That's a jump of 12,000 over the year before. . . . The Strafford, Pennsylvania, Public Library has installed a coin-operated TRS-80. The library committee had hoped that students would use the computer for homework, but instead most played games. At fifty cents for 15 minutes, a user can access any one of 24 programs, including one that teaches BASIC. The machine was installed and operated by the same company that supplies the library's photocopier. . . . The Mount Sinai School of Medicine in New York City will conduct an investigation for the Newspaper Guild into possible health problems associated with the use of video-display terminals. . . . "Go public, young firm!" seems to be the cry since Apple tried it last December. Later this year, Vector Graphic, Intertec

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8" system **$1375**

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Circle 294 on inquiry card.

BYTELINES

Data Systems, and Computer Factory Inc will follow Apple's lead. . . . New World Computer Company, Costa Mesa, California, has a novel way to provide Winchester hard-disk backup. Its new 5-inch floppy-disk drives have both fixed storage and a removable cartridge. New World has a drive with 4 megabytes fixed and 4 megabytes removable. It costs less than $1200. . . . Micropolis Corporation will soon start shipping 5-inch floppy-disk drives with 2.2 megabytes formatted storage. . . . Apple will soon offer a videotext interface that will allow the Apple II and III computers to access Canada's Telidon system. AT&T has also decided to make its videotext Telidon-compatible. These systems can deliver computerized data to your home via either cable television, telephone lines, FM subcarrier, or unused television scan lines. Observers expect future enhancements of videotext to provide message/teleconferencing, picture manipulation/animation, and downloading of data files from large systems to personal computers. . . .

Random Rumors: Word is that HP's (Hewlett-Packard's) personal-computer operations recently split off from the small-computer division and is now a separate entity. HP will soon introduce a multicolor plotter for its Series 80 personal computers. . . Cromemco, one of the leaders in S-100 Z80-based systems, is expected to release a 68000-based 16-bit processor card that includes a Z80 coprocessor. Rumor is that Cromemco has been working on the card for almost two years. . . . Expect Godbout Electronics to introduce 68000 and 8086 S-100 cards before year's end. . . . It's rumored that DEC (Digital Equipment Corporation) is about to release a personal computer, as HP has already done. HP's system is called the HP-125 and uses a Z80. DEC's desk-top unit will probably contain a Winchester hard-disk drive and either an LSI-11 or a standard processor like the Z80. DEC is already using Microsoft BASIC in its GIGI graphics terminal. . .

TRS-80 Meets IBM: Radio Shack has three new software packages that allow various forms of communication between the TRS-80 Model II and IBM mainframe equipment. The first is Reformatter. It converts data on Model II TRSDOS 5-inch floppy disks to the standard IBM format (3741 single-density). This means that Model IIs can now be used for off-line data entry in businesses where System 360/370 or other 3741-compatible equipment is employed. The other programs allow "bisync" (binary synchronous) communications by emulating the IBM 3270 and 3780. The Model IIs serve as online and remote job-entry terminals for IBM 3270- and 3780-compatible equipment. Reformatter sells for $249; the bisync packages sell for $995 each, which includes installation by Radio Shack.

MAIL: *I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed stamped envelope.*

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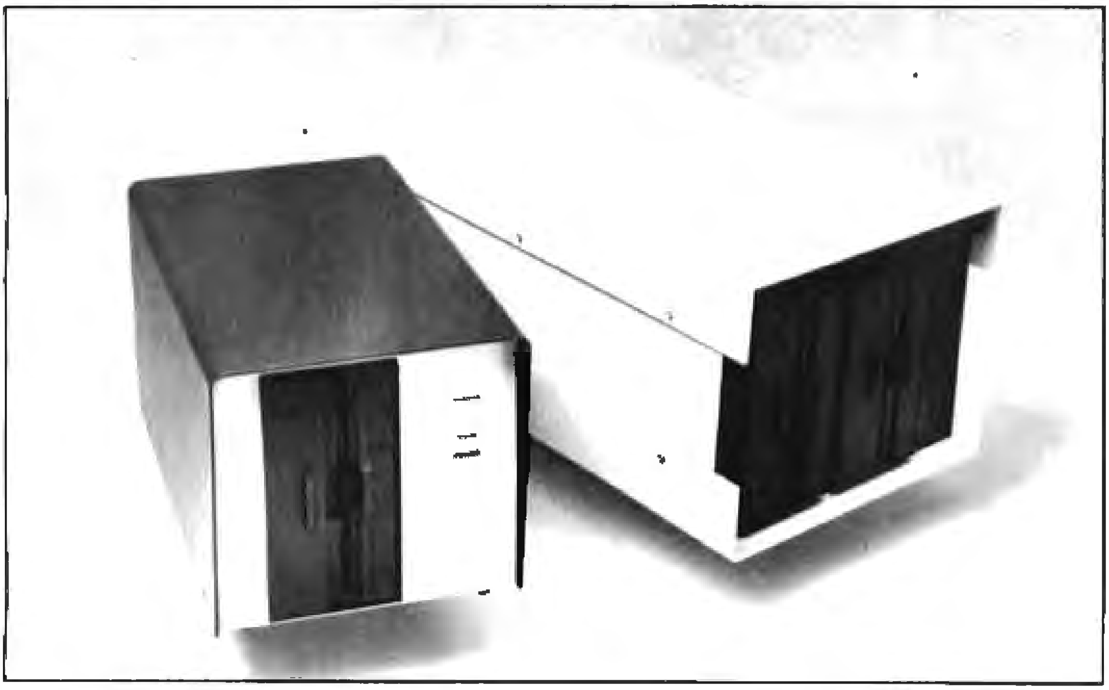
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Ask BYTE

Conducted by Steve Ciarcia

Mail-Order Forum

Dear Steve,

In July 1979, I was enticed by the savings of buying a Radio Shack TRS-80 from a mail-order firm. I chose a company that is still advertising in BYTE today—Pan American Electronics (it had a different name in 1979). I confirmed with the company that its TRS-80s were covered by the Tandy warranty. Still skeptical, I called the TRS-80 Hot Line. To my surprise, I was firmly discouraged from doing business with Pan American and was told that most mail-order TRS-80s were defective. I then called the Tandy World Headquarters and asked for the division manager responsible for Pan American. He assured me that Pan American was legitimate. He couldn't understand the comments from the Hot Line.

I decided to risk it (after all, I'd be covered by the warranty) and sent my check. My TRS-80 arrived, but it did not work. Pan American was very nice and said I could either return it for a refund or exchange, or take it to a local Radio Shack for free warranty service. I did the latter and a loose wire was repaired in 48 hours.

A few months later, contrary to my advice, a friend ordered from Pan American. His TRS-80 had a defective keyboard and was repaired by our local Radio Shack Center. Just recently, another friend received defective disk drives from some other "Authorized Radio Shack Sales Center."

In all three cases, the warranty service was done, and, hence, we are satisfied customers. However, our experiences support the Hot Line's accusations. Is Tandy pushing defective merchandise through mail-order stores?

Jeff Goodling
Allentown PA

Dear Steve,

I was concerned about buying a TRS-80 by mail, not because I was afraid of a rip-off, but because I'd heard rumors that local stores were being difficult about post-sale support.

To see for myself, I went to a Radio Shack Computer Center in Glendale, California, to check the price on a Model II with a printer, for my own use. The quote I got was about $1000 higher than I could get by mail (even forgetting the tax). When I mentioned to the salesman that mail order was much cheaper, he said, in effect, try to get support: the mail-order company won't support the machine, and neither would he unless I bought a $1300 service contract. He was pretty hostile about the whole idea that I might want to save a thousand bucks. He so soured me on the idea of a Model II that I've crossed it off my list of possibles.

At the same time, I was looking for a word processor for business purposes. I checked most of the big companies (Wang, Lanier, IBM, etc) and got a shock: all of them carry their own financing amortized over five years, but Radio Shack does not. Radio Shack, on the other hand, forces you to an outside lender, no matter who you are. We're an old company with plenty of credit, but to Radio Shack it makes no difference. Also, Radio Shack's service contract costs from $400 to $800 more than the rest.

It seems that Radio Shack simply isn't interested in the business market—at least it's never going to get it with that kind of financial attitude. Radio Shack's machines are initially cheaper, true, but over five years, with the service, they come out looking very bad. Plus, the attitude of the people associated with the places I talked to left something to be desired.

David Storti
Los Angeles CA

Perhaps it is best if Radio Shack responds directly. Pan American Electronics' reply follows. . . . **Steve**

Radio Shack Replies:

I can't believe anyone can think we're "pushing defective merchandise through mail-order stores"! That's absurd . . . our reputation would suffer, and we'd end up paying for the repairs anyway. I'd bet the reason Mr Goodling and his friends experienced problems was due to the extra shipping time and mileage. If a local store or dealer had delivered the equipment to the user, it could have been checked out on the spot before delivery.

Any Radio Shack employee telling a customer not to buy from a dealer is speaking against company policy. There are obvious advantages to buying locally, whether through a company store or authorized dealer: checkout prior to delivery and a salesman naturally more anxious to help "his customer" with any problems after the sale. A customer who spends money elsewhere and needs service is very likely to be a lower priority. That's not policy, just a commonsense assessment of human nature at work. Our store personnel are required to help any customer with repairs in a timely fashion. Warranty service requires proof of purchase from a Radio Shack store or authorized dealer. There are some folks selling TRS-80s who aren't authorized dealers, and there is no pass-through warranty if you buy from one of them.

I'm sorry Mr Storti doesn't like our prices or our credit policies. There are always people who can work on less margin, some, it seems, on no margin. We know what it takes to continue our service network and still keep our stockholders happy: Hot Line, Newsletter, new hardware and software development, etc.

As to the credit question, we simply aren't in the time-payment business: Why not criticize the finance company for not manufacturing computers? We offer a leasing program, but apparently it didn't meet Mr Storti's requirements.

I really believe that Radio Shack's attitude toward our customers is good. A salesperson (ours or anyone else's) will resist losing a sale and may naturally be less than enthusiastic about furnishing support to someone else's customer. I apologize to anyone who has received other than courteous treatment from one of our employees in this situation, or who has been led to believe that we as a company condone less than full support on a purchase from an authorized outlet. It just isn't true.

We'd like to be all things to all customers, but we know

Circle 274 on inquiry card.

we'll lose some customers to the competition. I'm at a loss to understand why Mr Storti's decision to buy from someone else should cause him to have such strong feelings against us.

Ed Juge, Director
Computer Merchandising
Radio Shack
Ft Worth TX

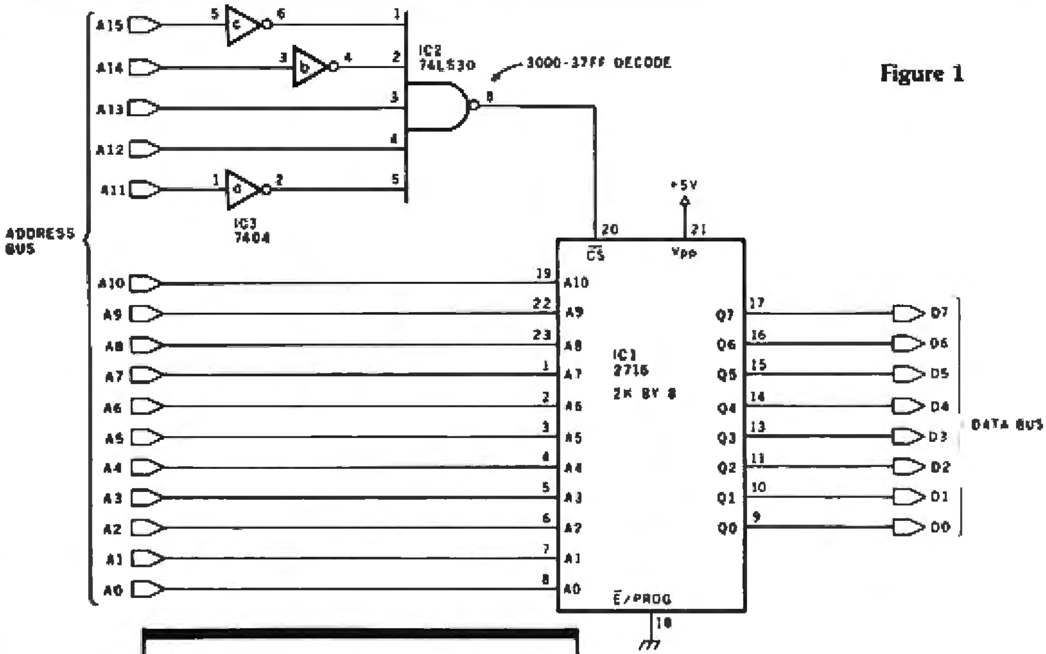


Figure 1

Number	Type	+5V	GND
IC1	2716	24	12
IC2	7430	14	7
IC3	7404	14	7

Obviously the sort of scare tactics that Mr Goodling experienced by Tandy (Radio Shack) personnel is not appreciated by Pan American Electronics or other dealers (i.e., Authorized Sales Centers). It is unfortunate that some Tandy personnel will try to make a sale or express their competitive nature between the two divisions (company and franchised/dealers) in such a way.

The facts are that the merchandise is the same. The vast majority of those who purchase from independent Radio Shack dealers are very happy with the merchandise and the personal service they receive from the small independent dealer. The added advantage of buying from an independent dealer is that they will often give their customers a better price for exactly the same merchandise.

Radio Shack dealers are not usually located in large cities. Major metropolitan areas are reserved for Radio Shack's company stores. The only access dealers have to the larger metropolitan areas is by advertising in magazines like BYTE and by offering consumers a better price for the same merchandise.

The dealers' profit margin is smaller than the company stores', so we sacrifice a lot by discounting. We feel, however, that discounting merchandise is an honest way to make a living. We feel it is inappropriate and unethical to make unwarranted threats or to spread lies about our main supplier and our major competitor simply to make an extra dollar.

Dan Frank, President

Pan American Electronics
Mission TX

In Need of a Way to the PROM

Dear Steve,

I want to use my TRS-80 Model I and Model III to develop useful programs, and I need peripherals to accomplish the task. Your articles on parallel and serial I/O (input/output) were very helpful in this regard. (See "I/O Expansion for the Radio Shack TRS-80, Part 1: Principles of Parallel Ports," May 1980 BYTE, page 22 and "Part 2: Serial Ports," June 1980 BYTE, page 42.)

One area that I would like to pursue is that of placing application software in an external PROM (programmable read-only memory). Thus, the application program would not have to be loaded each time it is used.

How to implement an external PROM memory with the TRS-80 expansion port is not clear to me. Can you help?

Frank Fitzgerald
East Northport NY

According to Radio Shack's Level II BASIC reference manual for the TRS-80 Model I, there is a reserved (blank) area of memory between 3000 and 3BFF hexadecimal. It's quite possible to configure a 2 K-byte EPROM (erasable PROM) to fit within that address space so that it can be accessed during a program.

Figure 1 is a schematic that demonstrates how this could be attached. You place an applications program in an EPROM in this address space, and whenever you wish to run the program, all you do is jump to address location 3000 hexadecimal and execute.

As for the TRS-80 Model III, this address space appears to be reserved for a system PROM. I haven't actually dismantled a Model III yet to see if this reference is a "phantom" PROM. . . . **Steve**

Getting on the Right Trak

Dear Steve,

I found your February 1981 "Circuit Cellar" article very interesting. (See "A Computer-Controlled Tank," page 44.) Since I fiddle with robotics, I would love to try out this ingenious toy. The only problem is that I can't find a store that sells the Big Trak. Could you give me the address of the Milton Bradley company?

Am I correct in assuming that the only parts I must specially order to build this are the Exar Integrated Systems phase-locked loop and the modem listed at the back of the article?

Marc Weigel
Delta, British Columbia, Canada

The address you want is Milton Bradley Company, MB Electronics Division, Springfield MA 01101.

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Regarding the components necessary to modify the Big Trak as I did, you would need two modem boards. If purchased as kits from the Micro Mint, 917 Midway, Woodmere NY 11598, they include the XR-2211 phase-locked loop and all other components. Other than that you would have to buy the UART (universal asynchronus receiver/transmitter) and CMOS (complementary metal-oxide semiconductor) integrated circuits. Many advertisers in the back pages of BYTE sell these items. . . . **Steve**

Board Inquiries

Dear Steve,

Is someone going to make available kits or printed-circuit boards for the project you described in "Build a Low-Cost Logic Analyzer" (April 1981 BYTE, page 36)?

Ivan Whitehouse
Goldendale WA

I completely misjudged the interest in my logic-analyzer project. The only unit I made was the prototype; I figured the interest would be general, but not enough to warrant the expense of having a printed-circuit board made. As you know, printed circuits are available for many of the projects that I present in BYTE, but I usually have some indication beforehand *that there will be a reasonable demand.*

Unfortunately, it's a little late for me to start the long procedure of designing a board, with so many new things to work on. I'll be sure to gauge response in the future, and there will continue to be printed-circuit boards for many of my projects.

If you want a complete list of all the printed-circuit boards available from my previous articles, drop a note to the Micromint, 917 Midway, Woodmere NY 11598 and request a catalog. . . . **Steve**

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, send your questions by electronic mail or chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies will be given as time permits. Please enclose a self-addressed, stamped envelope, and be sure to include "Ask BYTE" in the address.

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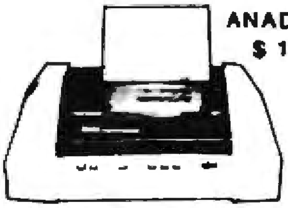
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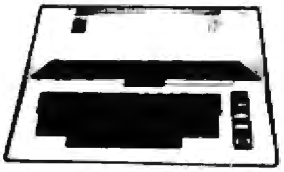
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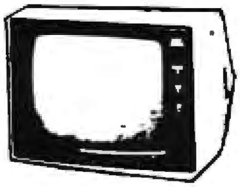


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Event Queue

October 1981

October-November

Workshops from Virginia Polytech, Virginia Polytechnic Institute and State University, Blacksburg VA. Workshops on microcomputer-design interfacing and programming, digital electronics for automation and instrumentation, and sessions using the TRS-80 are part of the curriculum. All workshops are hands-on with participants designing and testing concepts on the actual hardware. Contact Dr Lindy Leffel, Virginia Polytechnic Institute and State University, Blacksburg VA 24061, (703) 961-5241.

October-January

Electronics Magazine Seminars, various sites throughout the US. *Electronics* magazine and the McGraw-Hill Seminar Center are sponsoring seminars for engineers and managers. Subjects range from digital electronics to microprocessor-system design. Other topics include programming, speech technology and synthesis, microprocessor interfacing, and a hands-on microprocessor workshop. If a company has 10 or more people wanting to take a course, the seminar will be held at the company's plant. For details, contact Carol Clark, c/o McGraw-Hill Seminar Center, 305 Madison Ave, Rm 3112, New York NY 10017, (212) 687-0243.

October 7-9

Institute on Microcomputers for Instruction and Research in Higher Education, Jane S McKimmon Center, North Carolina State University, Raleigh NC. The institute is designed to help high-level educators learn about the microcomputer and the role it can play in higher education. Contact Joyce Currie, c/o North Carolina Educational Computing Service, POB 12035, Research Triangle Park NC 27709, (919) 549-0671.

October 7-21

The 1981 Far East Computer Tour, Japan, South Korea, Taiwan, and Hong Kong. This tour group will visit various computer-related conferences and exhibitions throughout the Far East. Transportation for this three-week tour, plus shows, meals, and other items are included in trip packages, ranging in price from $2290 to $3095. For more information, contact Terry Butler, Commerce Tours International Inc, 870 Market St, Suite 742-744, San Francisco CA 94102, (415) 433-3072.

October 9-11

Rhode Island Computer and Video Electronics Show, Providence Civic Center, Providence RI. This is the first major computer exhibition and show to be held in Rhode Island. Exhibitors and sales teams will present the latest in computers and video products for business, industry, government, education, and home use. Contact New Leaf Productions, Suite 335, 77 Ives St, Providence RI 02906, (617) 679-0089.

October 12-15

Information Management Exposition and Conference: INFO 81, Coliseum, New York NY. Discussions on prepackaged, customized prepackaged, and custom-designed software will complement hardware and software exhibits. For more information, contact Clapp & Poliak Inc, 245 Park Ave, New York NY 10167, (212) 661-8410.

October 13-15

Understanding and Using Computer Graphics, New York NY. Headed by Carl Machover, this two-day seminar examines the state of the art in graphic systems. The focus will be on hardware, software, and applications. Contact Bob Sanzo, c/o Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

October 15-18

The Third Annual Northeast Computer Show and Office Equipment Exposition, Hynes Auditorium, Boston MA. This show will feature hardware, software, and supplies for business, education, government, home, and office use. Office systems and equipment will also be shown. Contact National Computer Shows, 824 Boylston St, Chestnut Hill MA 02167, (617) 739-2000.

October 16-23

The Fourteenth Brazilian Computer Conference and Exhibit, Anhembi Convention and Exhibit Halls, São Paulo, Brazil. This conference will feature technical talks, conference tutorials, roundtable discussions, and special events. Computer-aided design and manufacture in developing countries will also be discussed. Contact Sucesu São Paulo, Rua Tabapuã, 627-1.° andar, 04533, Saõ Paulo, S P, Brazil.

October 18-20

The Annual Conference of the New York State Association for Educational Data Systems (NYSAEDS), Syracuse NY. NYSAEDS is made up of people with an interest in computers and education. Workshops on the educational uses of microcomputer software will be held. Contact Don Ross, Ardsley High School, Ardsley NY 10502.

October 19-23

Wintek's Hand-On Microcomputer Workshop, Lafayette IN. Two- and three-day workshops in microprocessor hardware, software, and interfacing will be offered at Wintek's corporate headquarters. A single-board computer, including a 6800 microprocessor, programmable memory, serial and parallel input/output, and a 1 K-byte ROM (read-only memory) containing a monitor/debug program, will be given to the participants of this workshop. Tuition is $50 per day. Contact Wintek Corporation, 1801 South St, Lafayette IN 47904, (317) 742-8428.

October 19-23

Systems '81, Munich, West Germany. Computer systems and their applications will be featured. Additional information is available from Kallman Associates, 30 Journal Sq, Jersey City NJ 07306, (201) 653-3304.

October 20-22

The Annual Government-Industry Data Exchange Program (GIDEP) Workshop, Rickey's Hyatt House, Palo Alto CA. The GIDEP annual workshop is open to anyone interested in the exchange of technical information relating to engineering, failure experience, reliability, and maintainability. Contact the Officer-in-Charge, GIDEP Operations Center, Corona CA 91720.

October 20-22

Computerized Office Equipment Expo, Southwest, Astrohall, Houston TX. Approximately 100 exhibitors will present office equipment and supplies, including word-processing systems, at this show. Contact Cahners Exposition Group, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

October 20-23
Computer-Network Design and Protocols, Boston MA. Integrated Computer Systems (ICS) will be presenting a course on fundamentals in computer communication-network concepts, technology, and implementation. Emphasis is on the practical aspects of network design, interfacing, protocols and packet switching. For a schedule of times and places for this course, contact Ruth Dordick, c/o Integrated Computer Systems, 3304 Pico Blvd, POB 5339, Santa Monica CA 90405, (800) 421-8166; in California (800) 352-8251.

October 21-24
COMPUTA 81, World Trade Center, Singapore. This international show attracts professionals and buyers from Hong Kong, India, and Sri Lanka. Additional information can be obtained from Kallman Associates, 30 Journal Sq, Jersey City NJ 07306, (201) 653-3304.

October 24-25
The Second Annual New Jersey Microcomputer Show and Fleamarket, Holiday Inn (north) Convention Center, Newark International Airport, Newark NJ. This show will feature 75 commercial exhibitors and more than 100 vendors. User-group meetings will be held. Registration is $5 for both days. Contact Kengore Corporation, 3001 Rt 27, Franklin Park NJ 08823, (201) 297-2526.

October 25-30
The Forty-Fourth Annual Meeting of the American Society for Information Science (ASIS), Washington Hilton Hotel, Washington DC. The theme for this meeting is "The Information Community: An Alliance for Progress." Among the topics to be addressed are information and creativity, information and society, and overcoming the barriers between information sciences. Contact ASIS, 1010 Sixteenth St, NW, Washington DC 20036, (202) 659-3644.

October 25-28
Issue '81: The Fifth Annual SPSS Software Users Convention, Jack Tar Hotel, San Francisco CA. Issue Inc, the independent, nonprofit association of SPSS software users and coordinators, is presenting its fifth annual convention. The primary purpose of the convention is to inform the user community about new SPSS products. Discussions of special applications will also be featured. Registration fees are $95 for members and $115 for nonmembers. For more information, contact Steve Hamburg, c/o Issue Inc, POB 8224, Chicago IL 60680, (312) 329-2400.

October 27-29
Computer Graphics 81, Regent Centre Hotel, London, England. Some of the topics to be covered are graphics systems: hardware and software; animation; image processing; simulation; and business and home graphics. An equipment exhibition will also be presented. For more information, contact Online Conferences Ltd, Argyle House, Northwood Hills, HA6 1TS, Middlesex, England.

October 29-November 1
Southeast Computer Show and Office Equipment Exposition, Atlanta Civic Center, Atlanta GA. For details, see October 15-18.

October 31-November 1
Computers in Ambulatory Medicine, Washington Sheraton, Washington DC. The Society for Advanced Medical Systems and the Society for Computer Medicine are sponsoring this conference. Basic and advanced tutorials on the fundamentals of medical computing will be featured along with technical sessions and presentations of papers. Fees are $115 for Society members and $165 for nonmembers. Contact SCM, 9650 Rockville Pike, Bethesda MD 20014, (301) 530-7120.

October 31-November 2
Annual Meeting of the American Society for Cybernetics, Washington Hilton Hotel, Washington DC. The theme for this meeting is "The New Cybernetics." A goal of the meeting will be to redefine the field of cybernetics and to provide a focus for the research efforts of the Society. Among the topics to be discussed are robotics, problem solving, pattern recognition, remote sensing, and communication networks. Contact Dr Laurence D Richards, Department of Administrative Science, Colby College, Waterville ME 04901, (207) 873-1131, ext 587.

November 1981

November 1-4
DPMA San Francisco '81, San Francisco Civic Center and Brooks Hall, San Francisco CA. This is DPMA's (Data Processing Management Association's) thirtieth annual conference and business exposition. Contact the Conference Coordinator, DPMA, 505 Busse Hwy, Park Ridge IL 60068, (312) 825-8124.

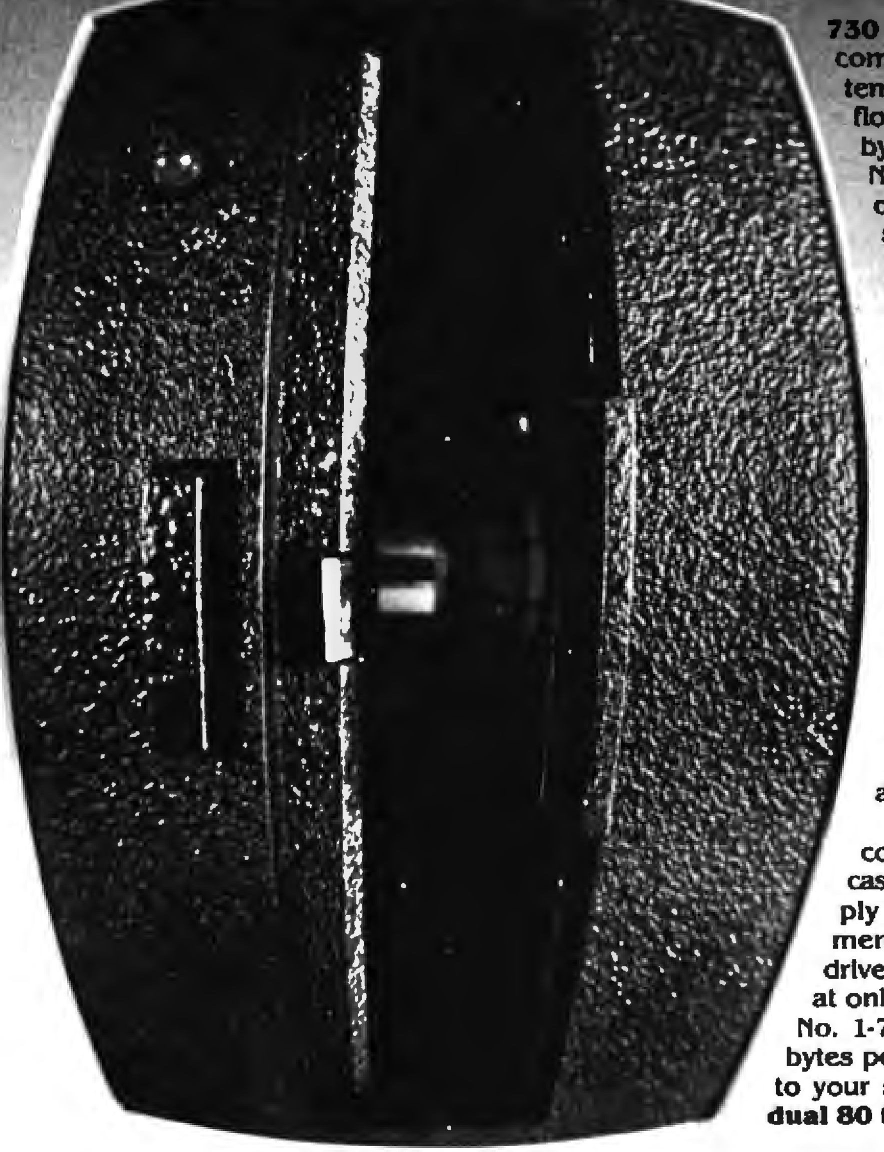
November 5
Invitational Computer Conference, Amsterdam, Netherlands. The Invitational Computer Conference is a one-day computer show designed for quantity buyers. Exhibits and seminars are featured. For details, contact B J Johnson & Associates Inc, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660, (714) 644-6037.

November 8-10
The Twelfth ACM North American Computer Chess Championship, Bonaventure Hotel, Los Angeles CA. A four-round, Swiss-style tournament is planned for this year's championship competition. In addition, a round-robin blitz tournament will be held. Games in this event proceed at a rate of 5 seconds per move. Belle, the current world champion, Chaos, Duchess, Nuchess, and L'Excentrique are among the programs being entered. For more information, contact Professor Monroe Newborn, School of Computer Science, McGill University, 805 Sherbrooke St West, Montreal, Quebec H3A 2K6, Canada.

November 9-10
Software Fair, Stouffers' Riverfront Towers, St Louis MO. This show is made up of software exhibitions from companies whose packages are in current use by members of the Southern and National Industrial Distributors Association. Distributors who are not members of these organizations can also exhibit their wares. Contact Don White or Tony Carroll, 1900 Arch St, Philadelphia PA 19103, (215) 564-3484.

November 9-11
ACM '81, Bonaventure Hotel, Los Angeles CA. This meeting will feature panel discussions on computers, software products in the 1980s, tutorials on computer-aided design, and a survey on the impact of robots on employment. Ray Bradbury and Dr Simon Ramo will speak. Computer exhibits and the North American Computer Chess Tournament will also be held. Contact ACM '81,

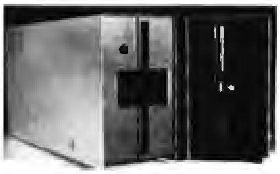
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POB 24059, Village Station, Los Angeles CA 90024, (213) 536-9735.

November 10-12
Midcon/81 Show and Convention, O'Hare Exposition Center and Hyatt Regency O'Hare, Chicago IL. Talks on microcomputers, energy, memory, communications, and consumer electronics will highlight this show. Contact Electronic Conventions Inc, 999 N Sepulveda Blvd, El Segundo CA 90245, (800) 421-6816; in California (213) 772-2965.

November 12
Invitational Computer Conference, Paris, France. For details, see November 5.

November 16-19
The Canadian Computer Show and Conference, International Centre of Commerce, Mississauga, Ontario Canada. For details, contact Reg Leckie, Industrial Trade Shows of Canada, 36 Butterick Rd, Toronto, Ontario, M8W 3Z8, Canada, (416) 252-7791.

November 17
Invitational Computer Conference, Milan, Italy. For details, see November 5.

November 17-19
Understanding and Using Computer Graphics, Atlanta GA. For details, see October 13-15.

November 19-20
Western Educational Computer Conference, San Francisco CA. Many of the computer-related talks at this conference will cover areas of interest to college instructors and administrators. For details, contact Ron P Langley, Data Processing Services, California State University–Long Beach, 1250 Bellflower Blvd, Long Beach CA 90840.

November 29-December 1
National Telecommunications Conference, New Orleans LA. This event is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) and the New Orleans chapter of the Communications Society Conference Board. Some of the papers to be presented will discuss communications electronics, including software, terminals, theory, and data and computer communications. Contact G Allan Ledbetter, South Central Bell, 365 Canal St, Rm 1360, New Orleans LA 70140, (504) 528-7350.

December 1981

December 1-3
Legal Info, Shoreham Hotel, Washington DC. Automating legal-information systems is the subject of this conference and exposition. Lawyers who are interested in using computers in their work are invited to attend. Contact Legal Info, 1730 N Lynn St, Suite 400, Arlington VA 22209, (703) 521-6209.

December 1-4
Computer-Network Design and Protocols, Washington DC. For details, see October 20-23.

December 3
California Computer Show, Hyatt Hotel, Palo Alto CA. For details and a schedule of upcoming shows, contact the Show Administrator, c/o Norm De Nardi Enterprises, 95 Main St, Los Altos CA 94022, (415) 941-8440.

December 9-11
1981 Winter Simulation Conference (WSC 81), Peachtree Plaza, Atlanta GA. WSC 81 will feature papers, panel discussions, tutorials on discrete and combined simulation and modeling. The conference will be organized into tutorial, methodology, and application sessions. For information, contact Claude M Delfosse, CACI Inc, 1815 N Fort Myer Dr, Arlington VA 22209, (703) 841-7800.

December 15-19
Gulf Computer Exhibition, Dubai International Trade Centre, Dubai, United Arab Emirates. IBM, NCR, Apple, Honeywell, Philips, Wang, Hewlett-Packard, Data General, and other well-known manufacturers will be represented at this first exhibition of computer equipment in Dubai. The scope of the show takes in systems ranging from microcomputers to mainframes. Details are available from the Trade Centre Management Company, POB 9292, Dubai, United Arab Emirates, Telex 47474 DITC EM, and from Diana Clifton Sewell, International Office, Seymour House, 17 Waterloo Pl, London, SE1Y 4AR, England.

December 16-18
The Twentieth IEEE Conference on Decision and Control (CDC), Vacation Village Hotel, San Diego CA. The CDC is the annual meeting of the IEEE (Institute of Electrical and Electronics Engineers) Control Systems Society. It is held in cooperation with the Society for Industrial and Applied Mathematics. The conference will include contributed and invited sessions plus tutorials and presentations in all aspects of the theory and applications of systems involving decision, control, and adaptation. Topics of interest include linear and nonlinear system theory, stability theory, large-scale system theory and decentralized control, estimation, identification, signal processing and stochastic control, and control systems. For more information, contact the Institute of Electrical and Electronics Engineers Inc, 445 Hoes Ln, Piscataway NJ 08854.

December 28-30
Computer Modeling of Linguistic Theory, Grand Hyatt Hotel, New York NY. The ACL (Association for Computational Linguistics) is sponsoring three sessions on computer modeling of linguistic theory in conjunction with the annual meeting of the Linguistic Society of America. New models for grammars and new strategies for parsing will be the areas of most attention. Readings of contributed papers will also be featured. Contact Stan Petrick, IBM Research Center, POB 218, Yorktown Heights NY 10598.■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

MULTI-USER OASIS HAS THE FEATURES PROS DEMAND. READ WHY.

(THEN COMPARE.)

Computer experts (the pros) usually have big computer experience. That's why when they shop system software for Z80 micros, they look for the big system features they're used to. And that's why they like Multi-User OASIS. You will too.

DATA INTEGRITY: FILE & AUTOMATIC RECORD LOCKING

The biggest challenge for any multi-user system is co-ordinating requests from several users to change the same record at the same time.

Without proper co-ordination, the confusion and problems of inaccurate or even destroyed data can be staggering.

Our File and Automatic Record Locking features solve these problems.

For example: normally all users can view a particular record at the same time. But, if that record is being updated by one user, automatic record locking will deny all other users access to the record until the up-date is completed. So records are always accurate, up-to-date and integrity is assured.

Pros demand file & automatic record locking. OASIS has it.

SYSTEM SECURITY: LOGON, PASSWORD & USER ACCOUNTING

Controlling who gets on your system and what they do once they're on it is the essence of system security.

Without this control, unauthorized users could access your programs and data and do what they like. A frightening prospect isn't it?

And multi-users can multiply the problem.

But with the Logon, Password and Privilege Level features of Multi-User OASIS, a system manager can specify for each user which programs and files may be accessed—and for what purpose.

Security is further enhanced by User Accounting—a feature that lets you keep a history of which user has been logged on, when and for how long.

Pros insist on these security features. OASIS has them.

EFFICIENCY: RE-ENTRANT BASIC

A multi-user system is often not even practical on computers limited to 64K memory.

OASIS Re-entrant BASIC makes it practical.

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Because all users use a single run-time BASIC module, to execute their compiled programs, less memory is needed. Even if you have more than 64K, your pay-off is cost saving and more efficient use of all the memory you have available—because it services more users.

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Multi-User OASIS supports as many as 16 terminals and can run in as little as 56K memory. Or, with bank switching, as much as 784K.

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And there's our BASIC—a compiler, interpreter and debugger all in one. An OASIS exclusive.

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Our documentation is recognized as some of the best, most extensive, in the industry. And, of course, there's plenty of application software.

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MULTI-USER	350	17.50
BASIC COMPILER/INTERPRETER/DEBUGGER	100	15.00
RE-ENTRANT BASIC COMPILER/INTERPRETER/DEBUGGER	150	15.00
DEVELOPMENT PACKAGE (Macro Assembler; Linkage Editor, Debugger)	150	25.00
TEXT EDITOR & SCRIPT PROCESSOR	150	15.00
DIAGNOSTIC & CONVERSION UTILITIES (Memory Test, Assembly Language, Converters, File Recovery, Disk Test, File Copy from other OS, etc.)	100	15.00
COMMUNICATIONS PACKAGE (Terminal Emulator, File Send & Receive)	100	15.00
PACKAGE PRICE (All of Above) SINGLE-USER	500	60.00
MULTI-USER	850	60.00
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CARD GAMES

BRIDGE 2.0 (Available for all computers) Price: $17.95 Cassette/$21.95 Diskette
An all-inclusive version of the most popular of card games. This program both BIDS and PLAYS either contract or duplicate bridge. Depending on the contract, your computer opponents will either play the offense OR defense. If you bid too high, the computer will double your contract! BRIDGE 2.0 provides challenging entertainment for advanced players and is an excellent learning tool for the bridge novice. See the software review in 80 Software Critique. Rated #1 by Creative Computing.

HEARTS 1.5 (Available for all computers) Price: $15.95 Cassette/$19.95 Diskette
An exciting and entertaining computer version of this popular card game. Hearts is a trick-oriented game in which the purpose is not to take any hearts or the queen of spades. Play against two computer opponents who are armed with hard-to-beat playing strategies. HEARTS 1.5 is an ideal game for introducing the uninitiated (your spouse) to computers. See the software review in 80 Software Critique.

STUD POKER (Atari only) Price: $15.95 Cassette/$19.95 Diskette
This is the classic gambler's card game. The computer deals the cards one at a time and you (and the computer) bet on what you see. The computer does not cheat and usually bets the odds. However, it sometimes bluffs! Also included is a five card draw poker betting practice program. This package will run on a 16K ATARI. Color, graphics, sound. See review in COMPUTE.

POKER PARTY (Available for all computers) Price: $17.95 Cassette/$21.95 Diskette
POKER PARTY is a draw poker simulation based on the book, POKER, by Oswald Jacoby. This is the most comprehensive version available for microcomputers. The party consists of yourself and six other (computer) players. Each of these players (you will get to know them) has a different personality in the form of a varying propensity to bluff or fold under pressure. Practice with POKER PARTY before going to that expensive game tonight! Apple Cassette and diskette versions require a 32 K (or larger) Apple II.

CRIBBAGE 2.0 (TRS-80 only) Price: $14.95 Cassette/$18.95 Diskette
This is simply the best cribbage game available. It is an excellent program for the cribbage player in search of a worthy opponent as well as for the novice wishing to improve his game. The graphics are superb and assembly language routines provide rapid execution. See the software review in 80 Software Critique.

THOUGHT PROVOKERS

MANAGEMENT SIMULATOR (Atari, North Star and CP/M only) Price: $19.95 Cassette $23.95 Diskette
This program is both an excellent teaching tool as well as a stimulating intellectual game. Based upon similar games played at graduate business schools, each player or team controls a company which manufactures three products. Each player attempts to outperform the competitors by setting selling prices, production schedules, marketing and design expenditures etc. The most successful firm is the one with the highest stock price when the simulation ends.

FLIGHT SIMULATOR (Available for all computers) Price: $17.95 Cassette/$21.95 Diskette
A realistic and extensive mathematical simulation of take-off, flight and landing. The program utilizes aerodynamic equations and the characteristics of a real airfoil. You can practice instrument approaches and navigation using radials and compass headings. The more advanced flyer can also perform loops, half-rolls and similar aerobatic maneuvers. Although this program does not employ graphics, it is exciting and very addictive. See the software review in COMPUTRONICS. Runs in 16K Atari.

VALDEZ (Available for all computers) Price: $15.95 Cassette/$19.95 Diskette
VALDEZ is a computer simulation of supertanker navigation in the Prince William Sound/Valdez Narrows region of Alaska. Included in this simulation is a realistic and extensive 256 × 256 element map, portions of which may be viewed using the ship's alphanumeric radar display. The motion of the ship itself is accurately modeled mathematically. The simulation also contains a model for the tidal patterns in the region, as well as other traffic (outgoing tankers and drifting icebergs). Chart your course from the Gulf of Alaska to Valdez Harbor! See the software review in 80 Software Critique.

BACKGAMMON 2.0 (Atari, North Star and CP/M only) Price: $14.95 Cassette/$18.95 Diskette
This program tests your backgammon skills and will also improve your game. A human can compete against a computer or against another human. The computer can even play against itself. Either the human or the computer can double or generate dice rolls. Board positions can be created or saved for replay. BACKGAMMON 2.0 plays in accordance with the official rules of backgammon and is sure to provide many fascinating sessions of backgammon play.

CHECKERS 3.0 (PET only) Price: $16.95 Cassette/$20.95 Diskette
This is one of the most challenging checkers programs available. It has 10 levels of play and allows the user to change skill levels at any time. Although providing a very tough game at level 4-6, CHECKERS 3.0 is practically unbeatable at levels 9 and 10.

CHESS MASTER (North Star and TRS-80 only) Price: $19.95 Cassette/$23.95 Diskette
This complete and very powerful program provides five levels of play. It includes castling, en passant captures and the promotion of pawns. Additionally, the board may be preset before the start of play, permitting the examination of "book" plays. To maximize execution speed, the program is written in assembly language by SOFTWARE SPECIALISTS of California. Full graphics are employed in the TRS-80 version, and two widths of alphanumeric display are provided to accommodate North Star users.

LEM LANDER (32K Apple Disk only) Price: $16.95 Diskette
Pilot your LEM LANDER to a safe landing on any of nine different surfaces ranging from smooth to treacherous. The game paddles are used to control craft attitude and thrust. This is a real-time high res challenge!

FOREST FIRE! (Atari only) Price: $16.95 Cassette/$20.95 Diskette
Using excellent graphics and sound effects, this simulation puts you in the middle of a forest fire. Your job is to direct operations to put out the fire while compensating for changes in wind, weather and terrain. Not protecting valuable structures can result in stiff penalties. Life-like variables are provided to make FOREST FIRE! very suspenseful and challenging. No two games have the same setting and there are 3 levels of difficulty.

NOMINOES JIGSAW (Atari, Apple and TRS-80 only) Price: $16.95 Cassette/$20.95 Diskette
A jigsaw puzzle on your computer! Complete the puzzle by selecting your pieces from a table consisting of 60 different shapes. NOMINOES JIGSAW is a virtuoso programming effort. The graphics are superlative and the puzzle will challenge you with its three levels of difficulty. Scoring is based upon the number of guesses taken and by the difficulty of the board set up. See review in ELECTRONIC GAMES.

MONARCH (Atari only) Price: $11.95 Cassette/$15.95 Diskette
MONARCH is a fascinating economic simulation requiring you to survive an 8-year term as your nation's leader. You determine the amount of acreage devoted to industrial and agricultural use, how much food to distribute to the populace and how much should be spent on pollution control. You will find that all decisions involve a compromise and that it is not easy to make everyone happy.

CHOMPELO (Atari only) Price: $11.95 Cassette/$15.95 Diskette
CHOMPELO is really two challenging games in one. One is similar to NIM; you must bite off part of a cookie, but avoid taking the poisoned portion. The other game is the popular board game REVERSI. It fully uses the Atari's graphics capability, and is hard to beat. This package will run on a 16K system.

*ATARI, PET, TRS-80, NORTHSTAR, CP/M and IBM are registered trademarks and/or trademarks.

**Except where noted, all model I software is available for the Model III. TRS-80 diskettes are not supplied with DOS or BASIC.

AND MORE...

STARTREK 3.2 (Available for all computers) Price: $11.95 Cassette/$15.95 Diskette
This is the classic Startrek simulation, but with several new features. For example, the Klingons now shoot at the Enterprise without warning while also attacking starbases in other quadrants. The Klingons also attack with both light and heavy cruisers and move when shot at! The situation is hectic when the Enterprise is besieged by three heavy cruisers and a starbase S.O.S. is received! The Klingons get even! See the software reviews in A.N.A.L.O.G., 80 Software Critique and Game Merchandising.

BLACK HOLE (Apple only) Price: $14.95 Cassette/$18.95 Diskette
This is an exciting graphical simulation of the problems involved in closely observing a black hole with a space probe. The object is to enter and maintain, for a prescribed time, an orbit close to a small black hole. This is to be achieved without coming so near the anomaly that the tidal stress destroys the probe. Control of the craft is realistically simulated using side jets for rotation and main thrusters for acceleration. This program employs Hi-Res graphics and is educational as well as challenging.

SPACE TILT (Apple and Atari only) Price: $10.95 Cassette/$14.95 Diskette
Use the game paddles to tilt the plane of the TV screen to "roll" a ball into a hole in the screen. Sound simple? Not when the hole gets smaller and smaller! A built-in timer allows you to measure your skill against others in this habit-forming action game.

MOVING MAZE (Apple and Atari only) Price: $10.95 Cassette/$14.95 Diskette
MOVING MAZE employs the game paddles to direct a path from one side of a maze to the other. However, the maze is dynamically (and randomly) built and is continually being modified. The objective is to cross the maze without touching (or being hit by) a wall. Scoring is by an elapsed time indicator, and three levels of play are provided.

ALPHA FIGHTER (Atari only) Price: $14.95 Cassette/$18.95 Diskette
Two excellent graphics and action programs in one! ALPHA FIGHTER requires you to destroy the alien starships passing through your sector of the galaxy. ALPHA BASE is in the path of an alien UFO invasion; let five UFO's get by and the game ends. Both games require the joystick and get progressively more difficult the higher you score! ALPHA FIGHTER will run on 16K systems.

THE RINGS OF THE EMPIRE (Atari only) Price: $16.95 Cassette/$20.95 Diskette
The empire has developed a new battle station protected by rotating rings of energy. Each time you blast through the rings and destroy the station, the empire develops a new station with more protective rings. This exciting game runs on 16K systems, employs extensive graphics and sound and can be played by one or two players.

INTRUDER ALERT (Atari only) Price: $16.95 Cassette/$20.95 Diskette
This is a fast paced graphics game which places you in the middle of the "Dreadstar" having just stolen its plans. The droids have been alerted and are directed to destroy you at all costs. You must find and enter your ship to escape with the plans. Five levels of difficulty are provided. INTRUDER ALERT requires a joystick and will run on 16K systems.

GIANT SLALOM (Atari only) Price: $16.95 Cassette/$20.95 Diskette
This real-time action game is guaranteed addictive! Use the joystick to control your path through slalom courses consisting of both open and closed gates. Choose from different levels of difficulty, race against other players or simply take practice runs against the clock. GIANT SLALOM will run on 16K systems.

TRIPLE BLOCKADE (Atari only) Price: $14.95 Cassette/$18.95 Diskette
TRIPLE BLOCKADE is a two-or-three player graphics and sound action game. It is based on the classic video arcade game which millions have enjoyed. Using the Atari joysticks, the object is to direct your blockading line around the screen without running into your opponent(s)! Although the concept is simple, the combined graphics and sound effect lead to "high identity!"

GAMES PACK I (Available for all computers) Price: $10.95 Cassette/$14.95 Diskette
GAMES PACK I contains the classic computer games of BLACKJACK, LUNAR LANDER, CRAPS, HORSERACE, SWITCH and more. These games have been combined into one large program for ease in loading. They are individually accessed by a convenient menu. This collection is worth the price just for the DYNACOMP version of BLACKJACK.

GAMES PACK II (Available for all computers) Price: $10.95 Cassette/$14.95 Diskette
GAMES PACK II includes the games CRAZY EIGHTS, JOTTO, ACEY DUCEY, LIFE, WUMPUS and others. As with GAMES PACK I, all the games are loaded as one program and are called from a menu. You will particularly enjoy DYNACOMP's version of CRAZY EIGHTS.

Why pay $7.95 or more per program when you can buy a DYNACOMP collection for just $10.95!

MOON PROBE (Atari and North Star only) Price: $11.95 Cassette/$15.95 Diskette
This is an extremely challenging "lunar lander" program. The user must drop from orbit to land at a predetermined target on the moon's surface. You control the thrust and orientation of your craft plus direct the rate of descent and approach angle.

SPACE LANES (North Star only) Price: $16.95 Diskette
SPACE LANES is a simple but exciting space transportation game which involves up to four players (including the computer). The object is to form and expand space transportation companies in a competitive environment. The goal is to amass more net worth than your opponent. The economics include stock purchases and company mergers. Watch your wealth grow!

ADVENTURE

CRANSTON MANOR ADVENTURE (North Star and CP/M only) Price: $21.95 Diskette
At last! A comprehensive Adventure game for North Star and CP/M systems. CRANSTON MANOR ADVENTURE takes you into mysterious CRANSTON MANOR where you attempt to gather fabulous treasures. Lurking in the manor are wild animals and robots who will not give up the treasures without a fight. The number of rooms is greater and the associated descriptions are much more elaborate than the current popular series of Adventure programs, making this game the top in its class. Play can be stopped at any time and the status stored on diskette.

SPEECH SYNTHESIS

DYNACOMP is now distributing the new and revolutionary TYPE 'N-TALK™ (TNT) speech synthesizer from Votrax. Simply connect TNT to your computer's serial interface, enter text from the keyboard and hear the words spoken. TNT is the easiest-to-program speech synthesizer on the market. It uses the least amount of memory and provides the most flexible vocabulary available anywhere!

Price: $329.95 (Please add $4.00 for shipping and handling)

TNT Software

The following DYNACOMP programs are available for use with TNT:

STUD POKER (Atari, 24K)
NOMINOES JIGSAW (Atari, 24K)
TEACHER'S PET I (Atari and North Star)
BRIDGE 2.0 (North Star)
CHOMPELO (Atari, 24K)

Please specify "TNT" version when ordering

ABOUT DYNACOMP

DYNACOMP is a leading distributor of small system software with sales spanning the world (currently in excess of 40 countries). During the past two years we have greatly enlarged the DYNACOMP product line, but have maintained and improved our high level of quality and customer support. The achievement in quality is apparent from our many repeat customers and the software reviews in such publications as COMPUTRONICS, 80 Software Critique and A.N.A.L.O.G. Our customer support is as close as your phone. It is always friendly. The staff is highly trained and always willing to discuss products or give advice.

Clubs and Newsletters

Newsletter for Hams and Computerists

Dits & Bits, The W5YI Report, is published twice a month for the ham radio operator and microcomputer user. Articles on memory, FCC regulations, and other related topics are included. Contact the newsletter at POB 10101, Dallas TX 75207, (214) 690-1063.

Interested in a Central Bulletin-Board Service?

Michael Witt is interested in hearing from people who would like to develop a computer network in which the central system would place calls during the evening hours for reduced telephone rates. The system would be similar to other bulletin-board systems, except messages would be delivered and picked up by the central system instead of users calling in.

Contact Michael Witt, POB 55686, Valancia CA 91355.

Newsletter on Genealogy

Genealogical Computing is a bimonthly newsletter on personal-computer applications involving genealogy. Contact Sara Andereck, c/o Data Transfer Associates, 5102 Pommeroy Dr, Fairfax VA 22032, (703) 978-8490.

Swiss Computer Club

Founded in 1978, the Schweizer Computer Club already has more than 4000 members. Members own PET, Apple, Sorcerer, and other systems, and have a special CP/M group. The club publishes three newsletters: *Mikro- und Kleincomputer*, a bimonthly; *CBM/PET News*; and *Computerjournal*. Contact Ernst Erb, Schweizer Computer Club, Seeburgstrasse 18, CH-6002 Luzern, Switzerland.

Free Graphics Newsletter

Subscriptions to the *Dynamic Blackboard News*, are free. The *News* features customer applications, new products, technical notes, software news, and hints for graphics users. *Dynamic Blackboard News* is a publication of the Cambridge Development Laboratory. Contact Jean L Graef, Cambridge Development Laboratory, 36 Pleasant St, Watertown MA 02172, (617) 926-0869.

Newsletter on Graphics

Computer Graphics News is published by the National Computer Graphics Association in cooperation with Scherago Associates Inc. The tabloid serves as a news source for the computer-graphics community. For further information, contact Scherago Associates Inc, 1515 Broadway, New York NY 10036, (212) 730-1050.

Heath Users Group in California

Covering Riverside, San Bernardino, and West Los Angeles counties in Southern California, the Tri-County Heath Users Group welcomes members and visitors to its bimonthly meetings. Meetings are held the first Saturday of each month at the Heathkit Electronic Center 1555 N Orange Grove, in Pomona, and on the third Saturday of each month at the University of California-Riverside, Rm 1111, Watkins Facility. Meetings begin at 2 PM.

CP/M Users Group

The Sacramento Microcomputer Users Group is a CP/M users group that publishes a monthly newsletter called *Push & Pop*. Contact the group at POB 161513, Sacramento CA 95816, (916) 363-3962.

Pocatello Microcomputer Club

Members of the Pocatello Microcomputer Club use most of the popular computers on the market today. Anyone interested in computers is welcome to join. Contact the club at POB 8106, Pocatello ID 83209, (208) 232-4462.

PETs in Canada

The Toronto PET Users Group (TPUG) has a disk library available for members and nonmembers. The library has approximately 1400 programs provided by TPUG members and from other clubs. Membership is encouraged even if you live too far away to attend meetings. Contact TPUG, c/o Chris Bennett, 381 Lawrence Ave West, Toronto, Ontario, M5M 1B9, Canada, (416) 783-1645.

Science Network and Newsletter

The *COGNET Newsletter* seeks to disseminate information on cognitive simulation, computational linguistics, and artificial intelligence. The Center for Cognitive Science is also working on a computer network for those involved in these areas of research. For details, contact *COGNET*, Center for Cognitive Science, POB 1911, Brown University, Providence RI 02912.■

BYTE's Bits

Industry's Eyes on New LISP Computer

LMI has been granted a license from the Artificial Intelligence Laboratory of MIT (Massachusetts Institute of Technology) to construct and commercially market the MIT CADR machine. This system is specifically designed as a programmer environment for LISP. According to an LMI spokesman, most LISP programs are developed on the DEC (Digital Equipment Corporation) PDP-10 mainframes, but the LMI system, although in the format of a personal computer, provides up to sixty-four times the virtual address space. The base price of the LMI machine is $80,000.

Until recently, LISP usage has been associated with research conducted at educational institutions. But now that Control Data Corporation and Texas Instruments have ordered LMI machines, LISP's commerical usage will be seen in expert systems, VLSI (very large-scale integrated) circuit design, and natural-language processing.

LMI is headquartered in Los Angeles, California.■

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A Closer Look at the TRS-80 Color Computer

Woody Baker
Rte 11, Box 4780
Lufkin TX 75901

People who have purchased the TRS-80 Color Computer know that Radio Shack is reluctant to disclose much information about the internal workings of its computers—preferring that all work requiring the opening of the outer case be performed by an authorized service center. However, it is possible to find much of this information; a bit of digging, a few phone calls to Fort Worth, and a disassembler from the Micro Works of Del Mar, California, enabled me to obtain the information presented here.

The TRS-80 Color Computer is based on the Motorola 6809E microprocessor. [*The "E" indicates the series—in this case, the 6809 model capable of multiprocessing, although this capability is not used in the TRS-80 Color Computer....SM*] The unit uses a Motorola 6847 video-display-generator IC (integrated circuit) for the color display—meaning there are a number of memory locations within the computer that control which of the eleven modes the IC is in. If you know these locations, you can access the modes not provided by Radio Shack's software.

Memory Organization

The TRS-80 Color Computer uses page 0 (memory locations decimal 0000 through 0256) as a scratch pad. The Motorola 680X microprocessors all have the ability to use a special mode of addressing called *direct page* (the same as the 6502 *zero page* mode). The enhancement added to the 6809 is the ability to select which 256-byte page to treat as page 0. In order for the 6809 to maintain 680X-family compatibility, the default remains page 0. Microsoft followed this default in its BASIC interpreter written for the Color Computer—leaving most of the important memory locations within page 0.

Since Microsoft uses the same conventions in all its BASIC interpreters, it can be concluded that the BASIC in the Color Computer is organized in a manner similar to its BASIC for 6502-based computers. The pointers to the start and end of BASIC and the start and end of variables are the same. Also, the storage format is the same for BASIC lines (a 2-byte pointer to the start of the line, followed by a 2-byte line number, and then the token code terminated by a zero).

The Video Window

As shown in tables 1 through 4, the TRS-80 Color Computer allows a surprising degree of control to the programmer. The video window is unique in that it can be moved around within available memory, which in this case is from 0000 through 7FFF. You can set it to location 0 and watch the scratch-pad locations change as the computer is running. This is where the information summarized in table 4 comes from. In order to set the video memory to page 0, just POKE any value into decimal location 65480. When the POKE is executed, it clears bit 1 of the 7-bit binary word contained in the Motorola 6883 SAM (synchronous address multiplexer) that controls the base location of the video screen. To restore the video window to its normal location, POKE any value into location 65481—resetting bit 1.

The 6 bytes referred to in table 1 control the memory-mapping mode of the 6847 VDG (video display generator). The 6883 SAM IC maps memory into the video circuits and can be thought of as a 3-bit number that selects the amount of memory available to the VDG. This 3-bit register is controlled by the locations shown in table 1. The desired result can again be obtained by POKEing any values into these locations—toggling 3 bits into the SAM circuit. The VDG control lines are located in port 65314 and select the mode of the VDG. In order to switch the Color Computer into another graphics mode, you first set the available memory to match the mode, and then select the mode via the port. It's necessary to turn the control lines on at the port and also set the video memory size via the locations shown in table 2.

Table 2 shows the locations that control the base page of the video memory. In order to locate the base page, the TRS-80 Color Computer hardware takes the 7-bit word these 14 bytes specify and multiplies it by 512—resulting in the location of the base page.

Locations shown in table 3 are either used by the 6809 for interrupts or are assigned other functions by Radio Shack. Although I was told their names by a Radio Shack representative, I didn't find out their exact functions. Apparently, you can select four different clock speeds using these locations. Although I encourage you to experiment with them, it's easy to lose your video-sync signal when fooling with these locations.

Programmable-memory locations are shown in table 4. The keyboard buffer is terminated by a 0, and a PEEK(732) returns the token for the first keyword found

in the line. In order to use this as an input routine, you would need to preface each line with a REM statement—resulting in the first character after REM being located at 733. The input routine uses the same buffer but doesn't do any tokenizing. A flag may exist that disables the tokenizing routine. Once the keyboard-input

Hexadecimal Address	Decimal Address	Function
FFC0	65472	Clear V0
FFC1	65473	Set V0
FFC2	65474	Clear V1
FFC3	65475	Set V1
FFC4	65476	Clear V2
FFC5	65477	Set V2

Table 1: *The six locations within the TRS-80 Color Computer's programmable memory that control the memory-mapping mode of the Motorola 6847 VDG (video display generator). The graphics mode is selected via port 65314 and the available memory must be set to match the mode. See listing 1 for an example of a program that does this.*

Hexadecimal Address	Decimal Address	Function
FFC6	65478	Clear bit 0
FFC7	65479	Set bit 0
FFC8	65480	Clear bit 1
FFC9	65481	Set bit 1
FFCA	65482	Clear bit 2
FFCB	65483	Set bit 2
FFCC	65484	Clear bit 3
FFCD	65485	Set bit 3
FFCE	65486	Clear bit 4
FFCF	65487	Set bit 4
FFD0	65488	Clear bit 5
FFD1	65489	Set bit 5
FFD2	65490	Clear bit 6
FFD3	65491	Set bit 6
FFD4	65492	Clear bit 7
FFD5	65493	Set bit 7

Table 2: *The TRS-80 Color Computer's programmable-memory locations that control the base-page location of the video memory. In order to calculate the base-page location, the hardware multiplies the resulting 7-bit number contained in the Motorola 6883 SAM (synchronous address multiplexer) by 512.*

Hexadecimal Address	Decimal Address	Function
FFD6	65494	Bank switch
FFD7	65495	Clear bit 2 clk rate
FFD8	65496	Set bit 2 clk rate
FFD9	65497	Clear bit 1 clk rate
FFDA	65498	Set bit 1 clk rate
FFDB-FFDF	65499-65505	Memory size jumpers
FFF0-FFFF	65520-65535	6809 vectors

Table 3: *A few miscellaneous control and interrupt locations within programmable memory. Hexadecimal locations FFD7 through FFDA control the processor speed (nominally, 0.894 MHz). Although experimentation is encouraged, the user should be aware that these locations are tied to video-sync generation and may result in a temporary loss of video.*

Circle 97 on inquiry card.

routine and the character-output routine are located, machine-language programming should be much easier on the Color Computer.

Applications

Since the video screen can be moved around in memory via one of the registers in the SAM circuit, you can use the information presented here to page through memory. If you are in the alphanumeric-graphics mode (the default), you can obtain an ASCII snapshot of memory. All the characters in the ASCII code range will show up in the video display. Moving the window to the BASIC work space allows you to look at your BASIC program. If you do this before doing a CLOAD, you can watch memory filling up with a program. Since you can move the screen back and forth, you can think of it as a "paging-mode" terminal. With the appropriate software, you should also be able to make a sophisticated screen-oriented editor. You cannot go above hexadecimal 7FFF, or page 64.

Hexadecimal Address	Decimal Address	Function
19-1A	25-26	Pointer to start of BASIC
1B-1C	27-28	Pointer to end of program
1D-1E	29-30	Pointer to variables
1F-20	31-32	Pointer to start of arrays
88-89	136-137	Pointer to current cursor position
8C	140	Location of sound frequency
8E	142	Duration of sound
94	148	Cursor color
A8-AA	168-170	Jump vector to 43376
10C-10E	268-270	Jump vector to 43274
10F-111	271-273	Jump vector to 41046
112-114	274-276	Jump vector to 45974
11D-11F	285-287	Jump vector to 45509
2DD-3DC	733-988	Keyboard buffer
601	1535	Start of BASIC work space

Table 4: *BASIC control and other miscellaneous locations within page 0 of the TRS-80 Color Computer's programmable memory.*

Putting the computer in the 64 by 64 color mode (listing 1) lets you use only half the screen. However, since you know where the starting pointers to BASIC are, you can change them and move the BASIC program down in memory to allow you to use more memory for the screen. This is accomplished by POKEing the new address into locations 19 through 1A hexadecimal or 25 through 26 decimal, and then doing a NEW command by jumping to location AD19 (or 44313). Now you can use V0 through V2 to allocate more screen memory.

You can also go into other modes: POKEing a 240 into port 65413 puts you into high-resolution mode, which takes 6 K bytes of programmable memory for the screen. In this mode, everywhere there is a "1" in memory, a lit dot appears on the screen, and everywhere there is a "0" in memory, a black (unlit) dot appears on the screen.

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Listing 1: *A program for the TRS-80 Color Computer demonstrates video-mode switching. This program sets the computer to a 64- by 64-character graphics mode. Each byte maps into four consecutive blocks on the screen, with a 2-bit code used to indicate which of the four available colors (in this mode) each block will be. In this graphics mode, each horizontal line of blocks is 16 characters wide, as opposed to 32 characters (bytes) wide in the normal mode of operation. Since this mode requires 1 K bytes of programmable memory, with 512 bytes allocated to the screen, you can only work with the upper half of the video display. See the text for further details.*

```
5 POKE 65495,0:REM SPEED PROCESSOR UP
10 BA=1300:REM BASE OF THE CHARACTER
15 POKE 65314,129:POKE 65473,0:REM SET COLOR
   GRAPHICS MODE C
20 FOR I=1024 TO 1535:POKE I,0:NEXT I:REM PAINT ½
   SCREEN GREEN
30 FOR I=1 TO 8:REM 8 LINES PER CHARACTER
40 FOR J=1 TO 3:REM 3 BYTES PER LINE
50 READ A:POKE BA+(I*16)+J,A:REM PUT THE
   CHARACTER DOWN
60 NEXT J:NEXT I
70 GOTO 70:REM LOOP SO WE DON'T MESS DISPLAY UP
80 DATA 0,255,0,3,255,192,15,60,240,15,255,240,15,225,240
90 DATA 0,195,0,3,60,192,8,195,48
100 END
```

A rather interesting location is 148 (hexadecimal 92). This location changes madly when you put video into page 0. This is the so-called heartbeat of the system—the storage location for the color byte that specifies the color of the cursor. POKEing a 0 there makes the cursor go away.

The 6809 machine-code interrupt vectors at hexadecimal locations FFF0 through FFFF all point to programmable memory (except the reset vector). The reset vector points to cold-start BASIC. This routine is in ROM (read-only memory), and has the responsibility of resetting all other vectors and initializing memory. It checks if the machine has been on or has just been turned on. If it has just been turned on, it initializes most of the scratch-pad locations. If you just hit a reset, it leaves certain pointers alone, notably the pointers to your BASIC program.

Conclusion

There is much more to be learned about the TRS-80 Color Computer. I hope this article inspires you to go digging. I'd like to hear from people who discover other interesting facts about it. Hopefully, this information will give you a good start toward understanding your new computer. ■

[**Editor's Note:** *It's a little-known fact that Radio Shack publishes technical service manuals for all its computer products. These manuals are available to the general public and contain a wealth of "inside" information and troubleshooting procedures. The manuals are not stocked by Radio Shack dealers. Contact your local Radio Shack store for the price and ordering information. Also, see "What's Inside Radio Shack's Color Computer?" in the March 1981 BYTE, page 90....***SM**]

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Four Roads to Understanding Radio Shack's TRS-80

Yvon Kolya, POB 22, Peterborough NH 03458

The four books reviewed here purport to give assembly-language programmers a key to the mysteries of Radio Shack's TRS-80 Model I Level II ROM (read-only memory) and DOS (disk operating system). Because each book approaches the subject in a different way, it is difficult to compare them all in the framework of a general discussion, so I have considered them separately. At the conclusion of each review, I have outlined the book's strengths and weaknesses as an aid to the prospective buyer.

Pathways Through the ROM

George Blank, editor
Softside Publications
6 South St, Milford
NH 03055, 1979, 1980
116 pages, softcover
$19.95

Pathways Through the ROM is actually a compilation of several manuals and articles already available separately. They are:

- *The TRS-80 Disassembled Handbook* by Robert Richardson (the first nine chapters)
- SUPERMAP by Roger Fuller (chapter 10)
- HEX-MEM Monitor, a program by John T Phillipp (chapter 11; originally published in the February issue of *PROG/80*)
- Z80 Disassembler, a program by George Blank (chapter 12; originally published in the June issue of *PROG/80*)
- DOS Map by John Hartford (chapter 13)
- "The WD1771 Controller Specification Bulletin" (chapter 14; available from Western Digital Corporation)

By collecting these works in one volume, Softside Publications has simplified the programmer's chore of gathering information about Level II DOS routines and has significantly reduced the cost (separately, these six items would cost over $34).

The first nine chapters (from *The TRS-80 Disassembled Handbook*) cover decoding Level II ROM CALL locations; integer-, single-, and double-precision arithmetic; four short demonstration programs; ROM trig, exponent, and log routines; miscellaneous ROM routines; an alphabetical list of ROM CALL addresses; two programs—one in BASIC, the other in assembly code; and a short self-test.

In the introduction to his original work, Robert Richardson states that the handbook came out of a series of lectures he gave. Unfortunately, the lectures were very general; examples are included mainly in the demonstration programs. It is obvious that Richardson feels the readers should do their own experimentation, using his handbook as a beginning. He provides very little to guide you through the ROM beyond pointing out the road signs so that you won't get hopelessly lost.

The most valuable portions of Richardson's handbook are the various tables included. For example, three separate figures list the BASIC functions with the locations of their respective ASCII (American Standard Code for Information Interchange) representations in ROM; the locations of their CALL addresses (not the same locations as the ASCII codes); the addresses themselves in decimal form, in hexadecimal form, and in POKE form (decimal low-order byte followed by high-order byte, ie: 174-29 instead of 7598 decimal or 1DAE hexadecimal).

Chapter 10 is Roger Fuller's SUPERMAP, a listing of ROM entry addresses and what the code at each address does when accessed properly. Also provided is information on the various cassette-tape storage formats used by the ROM. All in all, this is an informative and useful chapter.

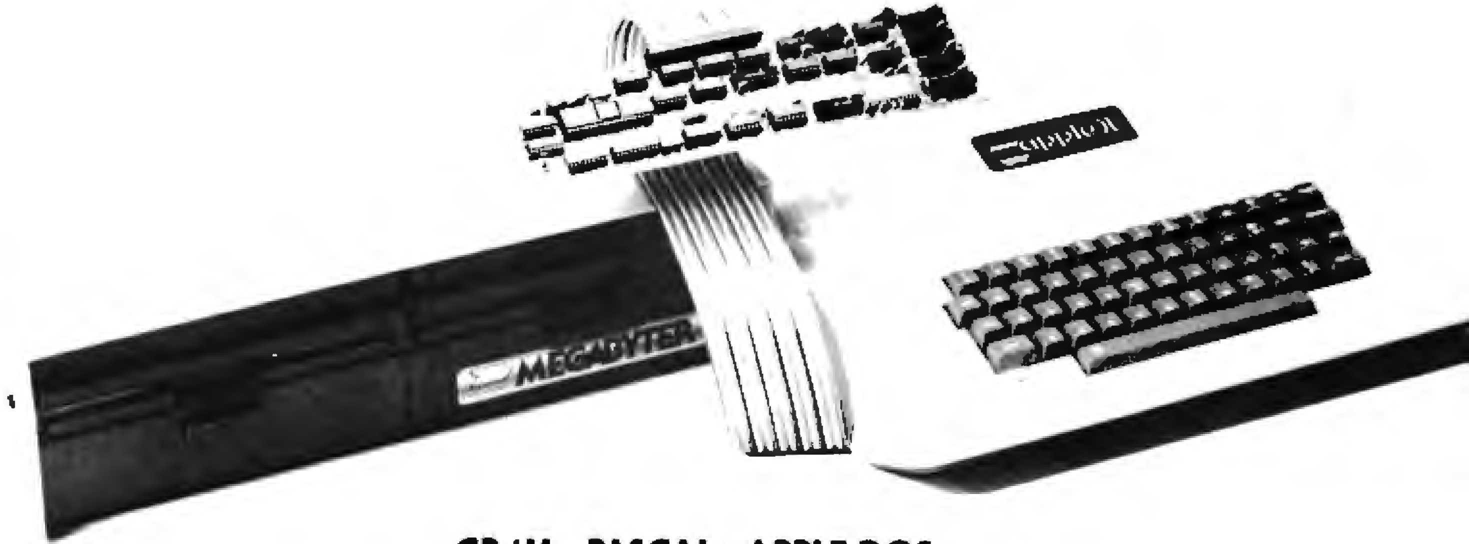
Chapter 11 contains the instructions and listing of a simple BASIC monitor. Its sole purpose is to provide several memory-examining capabilities, if you don't already have a monitor.

Chapter 12 is a Z80 object-code disassembler. It's handy, too, if you don't already have one.

Chapter 13, devoted to mapping TRSDOS and NEWDOS, is a valuable inclusion. The two *overlay* regions used by the DOSes are defined, and the addresses and uses of the various DOS systems are identified and labeled. All of the Radio Shack TRS-DOS system files (SYS0 to SYS6) are covered. Also given is the command structure necessary to call any of the DOS commands from an assembly-language program. This chapter and Chapter 10 make *Pathways Through the ROM* well worth the money, giving you information not available anywhere else.

Chapter 14 is merely the Western Digital FD1771-01 floppy-disk formatter controller specification sheets (17 pages). If you plan to write a program to access the disk drives directly without using any of the DOSes, these specification sheets are a must. This is definitely not a beginner's project. The specifications, written for expert assembly-language programmers, include command flow-

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charts, pin assignments, timing specifications, information on formatting tracks, disk read and write operations, and other technical information.

The last section, the appendix, is very confusing. The table of contents calls it a "Reference Table of Memory Contents." What it actually is I don't know. It contains the following:

- a decimal column going from 0 to 255
- a hexadecimal column counting from 0 to FF, matched to the decimal column
- a column labeled EXT, which makes sense only if it is related to the Z80 assembly-code mnemonics
- a column of the corresponding Z80 op codes, matched to the hexadecimal column (which seems to support the assumption about the EXT column)
- a column labeled ASCII for the numbers 0 through 127, which changes to GRAPHIC for the numbers 128 through 191, and changes a last time to TAB for the numbers 192 through 255
- a column labeled TRS-80 Controls for the numbers 0 through 63, changing to TRS-80 BASIC for the numbers 64 through 255.

None of these has anything to do with a table of memory contents.

Conclusions

- Unfortunately, *Pathways Through the ROM* is only a compilation of the separate works just discussed. No attempt has been made by the editor to tie these different items together into a cohesive whole. Each work uses a different approach and different writing style. This makes the manual difficult to read and at times a frustrating experience. It also means that some of the information is repeated needlessly.
- As if this didn't make it difficult enough, the manual itself is poorly put together (and I don't mean physically). There are numerous typographical errors and many outright editorial mistakes, including figures with incorrect or no labels, and references to figures which are not in the book. This is possibly the result of its being a hasty compilation of several different works.
- *Pathways Through the ROM* contains information on the floppy-disk controller and the DOS commands not present in the other ROM manuals I have seen. Because of this, it might be of use to the serious assembly-language programmer who has a disk system.

Inside Level II: A Programmer's Guide to the TRS-80 ROM

John Blattner and Bryan Mumford
Mumford Micro Systems, POB 435, Summerland CA 93067, 1980, 65 pages, softcover, $19.95

In their preface, the authors say the main objective of *Inside Level II* is "to provide the information necessary for utilizing these routines [stored in the ROM] in your own assembly-language programs." This is quite accurately accomplished. The second objective, which the book doesn't achieve, is "to detail an efficient scheme for linking assembly-language and BASIC programs."

To realize the first objective, the authors have selected the routines they believe will be of interest to assembly-language programmers, and have carefully outlined each step involved in their use. Thus, not all the routines in the ROM are ac-

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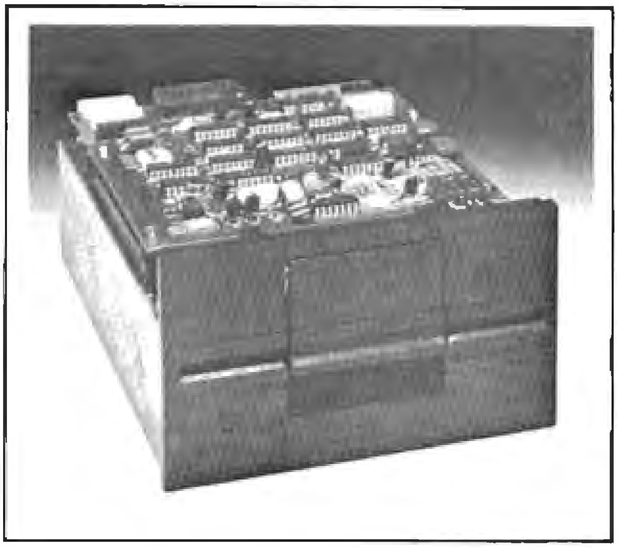
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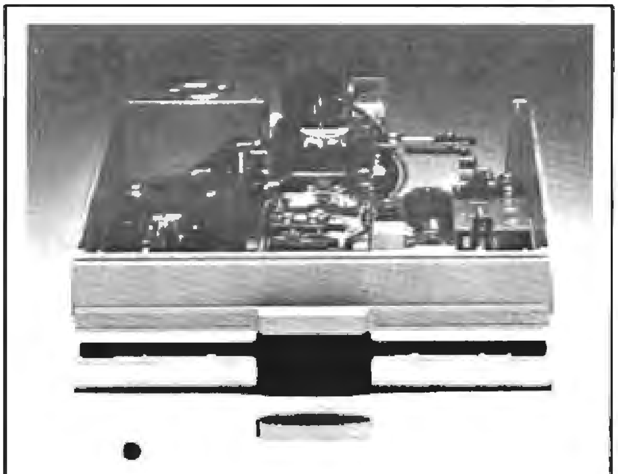
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Book Review

tually dealt with. For example, the AUTO, CLEAR, and EDIT commands are not even mentioned.

For each routine, you are told exactly what is being done, followed by the precise procedure in BASIC to get the desired result. You are also given warnings about what types of errors to expect, both in Level II and disk BASIC, and what you can do to prevent them.

The book's introduction is short (only three pages) and covers how the TRS-80 represents numbers, uses the registers, and links to disk BASIC.

The rest of the book is divided into three parts:

- the Level II ROM and reserved programmable memory
- linking assembly-language and BASIC programs together
- appendices

Part I (chapters 1 through 10) starts off by explaining exactly what each byte in reserved memory contains. For example, the bytes at hexadecimal addresses 40AA to 40AC hold the seed used by the TRS-80 random-number generator. This information is followed by the entry points to Level II commands and functions and the transfer points for disk BASIC commands. All this is in Chapter 1.

Chapter 2 tackles registers, buffers, and the passing of variables from storage to buffers and back.

Chapter 3 concerns the conversion routines for changing a numeric variable from one precision to another, such as converting a single-precision number to double precision or to an integer, or a numeric string to binary or vice versa. Examples are given of short routines that can be used to access the ROM properly from your own program.

Chapters 4 and 5 handle the arithmetic operations and the higher math functions (and even give the amount of time required by the routines to execute), while Chapter 6 explains the keyboard input, from single-character to numeric to string input.

Chapters 7 through 10 discuss the rest of the instructions, cassette I/O (input/output), video display, VARPTR (which returns the address of a variable), and the stack pointer.

Part II begins with Chapter 11, which, according to its title, is about assemblers and monitors. Actually, it merely suggests you use an assembler similar to Radio Shack's EDTASM and a monitor, preferably the one sold by Mumford Micro Systems (publisher of *Inside Level II*). Fortunately, this chapter is only one page long.

Chapter 12 gets down to the technique of mixing BASIC and machine-language programs. Unfortunately, the methods discussed are somewhat awkward. The authors believe that machine-language routines of a mixed program should reside in low memory, and they go to a great deal of trouble outlining how this can be done, covering CLOADing and CSAVEing techniques. Some of the advice is common sense (i.e., debug the machine-language routine before you combine it with the BASIC program and vice versa). Because of the difficulty of combining programs in this style, I think the authors have failed in their avowed purpose. They did not even consider the prospect of embedding the machine-language routines in BASIC REM (remark) statements. This is easily done by loading your monitor above the BASIC program and replacing the body of the REM statement with your machine-language routine.

Another important omission was an explanation of how to make your program a "load-and-go" type, eliminating the need to return to either the system level or the BASIC level after your program loads.

The three appendices are only two pages each. The first is a simple hexadecimal-to-decimal conversion chart, while the second is a machine-language program for recording a composite BASIC and machine-language program on tape (but the composite program must be in the format preferred by the authors, with the machine-language routines "below" the BASIC program). The last appendix is the most valuable, giving a machine-language program that allows faster recording of DATA tapes by shortening the length of the leader and the sync byte.

Like the other books reviewed here, it has no index; however, the table of contents is detailed and makes up for the lack of an index.

Conclusions

- All of the steps required by BASIC when accessing the ROM from your own program are carefully outlined: what to do, when to do it, and where to do it.
- Part II is of use only to programmers who do not write programs in pure machine language and must use hybrid programs instead.
- My only complaint might be that the book is too concise, with explanations a little too short for the beginner.
- I recommend this book to serious machine-language programmers.

The BOOK: Accessing the TRS-80 ROM

Raymond E Daly IV, Stephen C Hill, Roy Soltoff, Thomas B Stibolt Jr, and Richard P Wilkes
Insiders Software Consultants, POB 2441, Springfield VA 22152, 1980, 123 pages, softcover, $14.95

According to the introduction, *The BOOK* (volume I of a three-volume set) is dedicated to the math routines of Level II BASIC. It claims to be written for the novice to machine-language programming, while not "talking down" to the expert. I must say that the authors certainly have achieved their objectives.

The first three chapters (32 pages) deal with the formats, accumulators, and data manipulations for using the ROM math routines, as well as the actual functions. In the first chapter, you are given a leisurely and thorough explanation of how the TRS-80 Level II ROMs store and use memory addresses, binary numbers, and the memory accumulators. Numerous examples are used to make these techniques as clear as possible.

The second chapter details the ROM data-manipulation

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techniques and routines, with examples of how to move data from the ROM *work area* to your program's memory area and how to use the data-conversion routines (such as the ASCII string-to-binary number-conversion routine).

Chapter 3 gives accurate and complete instructions on interfacing the actual math routines to your own program. The authors have included a good deal of "extra" code in setting up their examples. This approach is particularly useful in illustrating good programming techniques and makes it much easier for the novice to use the routines immediately, but it makes it much harder to find out what the bare requirements are to use a ROM routine and to adapt the routines more precisely to your needs.

Chapter 4 is not simply a disassembly of the math routines of the ROM, but a completely commented source-code listing with established labels. This was probably done by disassembling the ROM and assigning labels and comments. This method gives the byte number, a label name (where applicable), the Z80 mnemonic (but not the extended mnemonics), and a comment field. It does not give the actual op codes stored at those bytes. This was probably an attempt to avoid infringement of Tandy (Radio Shack) and Microsoft copyrights. (Because this volume is devoted to the math routines, only that portion of the disassembly dealing with those routines has been reproduced in *The BOOK*.)

Start	End	Label	Description
0B3D	0B58	INTSNG	Take Integer of Single
0B59	0B9D	INTDBL	Take Integer of Double

Table 1

This disassembly is followed by Appendix A containing the whole label table for the entire Level II ROM, not just those labels dealing with the math routines. The authors say they did this to assist curious programmers in finding their way through the ROM. Each label's start and, where applicable, end address are printed as shown in table 1.

Appendix B contains three lengthy examples of how to use the routines in actual programs. Appendix C is a program listing of a disassembler in BASIC.

Conclusions

- *The BOOK*, like *Inside Level II*, is very thorough in its treatment of the math routines, but unlike *Inside Level II*, it gives numerous examples and copious explanations. This is a real help for the novice, and it also tends to prevent the expert from jumping to erroneous conclusions.
- Because of the use of labels in the disassembly, it is very easy to see and understand how the Level II ROMs actually operate.
- *The BOOK* does not give you the locations and procedures needed by the ROM; rather, it provides short, simple programs that use the ROM routines. For the novice, this could be a handicap in learning how to use the routines efficiently.

Microsoft BASIC Decoded & Other Mysteries for the TRS-80

James Farvour
IJG Computer Services
1260 W Foothill Blvd,
Upland CA 91786,
1981, 310 pages,
softcover, $29.95

Microsoft BASIC Decoded, the latest "ROM book" on the market, is by far the thickest and most complete to date. It is the second volume on the TRS-80 published by IJG Computer Services, the first being *TRS-80 Disk & Other Mysteries*.

Microsoft BASIC Decoded takes a completely different tack from the other books discussed here: it attempts to give a *total* overview of the Level II ROM operating system *and* Microsoft BASIC. It starts by explaining what is meant by an *operating system*, and what the TRS-80 has by comparison with this general idea.

Next, the book takes you through the process of turning on the TRS-80 computer, both with and without disk drives attached. It also tells you how the BASIC interpreter operates. Other chapters explain the ROM subroutines, cassette and disk I/O, addresses and tables used, and disk BASIC memory overlays.

Its best selling point, however, is the inclusion of a disassembly of the entire TRS-80 Model I Level II ROM set, both the old and the new ones, from hexadecimal 0000 all the way to hexadecimal 302A, with almost every line commented in plain English as to its purpose. The format

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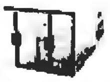
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is very straightforward:

byte number — Z80 op code — mnemonic — comment

The mnemonics are restricted solely to the primary commands because the printing of the extended mnemonics would probably be a violation of the copyright laws.

In an effort to make it simpler for you to use this disassembly, the book pages have been predrilled to fit a three-ring binder and the binding has been prepared for easy removal of this section. This is a brilliant idea, and I wonder why more publishers don't do this; there are many books that I wish had been made in this way.

Not only does the loose-leaf binder make it easier to work with the pages, but it also makes it possible for you to insert your own pages of comments wherever you want to. And that's not all: because most programmers will want to include the extended mnemonics in their binders, a simple scheme has been devised to accommodate this desire. Each page of the disassembly is a standard 8½- by 11-inch sheet of 66 lines (four of the lines are blank, to provide spacing at the top and the bottom). This means that any printer capable of printing 66 lines per 11-inch page will be able to produce a disassembly to match the book pages perfectly. The only qualification is that you have to use a disassembler that automatically paginates after printing 62 lines.

If you use the Apparat Disassembler, which is what the author used, you should have a perfect match to the book. This scheme is very well thought out. The book's disassembly even goes so far as to note the errors of disassembly that most disassemblers will make (i.e., the disassembler doesn't know when it is mistakenly decoding a table of addresses or ASCII messages to the operator).

All in all, the publisher and author have done a remarkably efficient job of making it as easy as possible for you to have a correct and complete disassembly of the TRS-80 Model I Level II ROMs. This disassembly is Chapter 8 of the book and occupies 246 pages. It covers the entire old ROM set that Radio Shack originally sold (it displayed RADIO SHACK LEVEL II BASIC when the machine was turned on). Chapter 7 (only three pages long) points out the few differences between the old ROM set and the new ROM set (which displays R/S LII BASIC). Without a doubt, these two chapters alone would have made a "best seller" in the personal-computer field.

As I mentioned before, the first six chapters are devoted to the gargantuan task of trying to tell you precisely how the Level II ROMs work, and they simply do not live up to the standard set in the last two chapters.

Chapter 1 contains the explanations of memory use, Level II operation, interpretation, and execution; and, in general, it provides a simple overview of just what it is that the Level II ROMs do to control the TRS-80 system.

The second chapter is a tremendous letdown. It is supposed to be a guide to accessing the different ROM subroutines, but it is poorly written and incomplete. The explanations are not simple, and the format used is not explained. There are no warnings as to possible problems arising from the use of routines; and the sample programs don't tell you what you need to know to use the routines.

Neither this chapter nor any of the others explains the method used by the ROMs to store numbers, except to note that integer numbers require 2 bytes of memory, single-precision numbers need 4 bytes, and double-precision numbers need 8 bytes. To balance this omission, the author has included a precise mathematical explanation of the formulas used by the ROM to compute the functions of sine, cosine, tangent, arctangent, exponentiation, natural logarithm, and square root. This information is not duplicated in any of the other books about the ROM.

Finally, not all of the subroutines that should have been included have been included. For example, Chapter 2 gives the routines used to turn on the cassette-drive motor, how to read and write the leader bytes, and how to read and write data. It does not tell you how to turn off the cassette motor, although you can find this information in the disassembly of Chapter 8 if you are patient.

Chapter 3, a considerable improvement over Chapter 2, concerns cassette and disk I/O formats and timing and includes timing diagrams for the cassette data. The disk section gives the controller commands—head seek, step, restore, etc. It goes into detail on the data formats on the disk, covering the GAT (granule allocation table), the HIT (hash index table), the disk DCBs (device-control blocks), and the directory sectors. In fact, the only other book that goes into more detail on the disk-data formats is *TRS-80 Disk & Other Mysteries.*

Chapter 4 is devoted to all of the tables used by the Level II ROMs and to lists of addresses of important routines. In addition to the table of Level II reserved words and their respective ROM addresses, there are tables of the hierarchy of arithmetic operations, data-conversion routines, and error codes. Other tables, which are built in memory by BASIC for program execution, include the Mode Table, the Program Statement Table, and the Literal-String Pool (where the garbage collection routine spends all of its time). This chapter is crammed with information, but it is written more for the expert programmer than for the novice.

Chapters 5 and 6 are example programs illustrating methods of using the ROM routines in your own programs to do such things as initiate your own new BASIC commands and using the DOS overlay concept in a BASIC program to execute a program longer than the available memory (i.e., run a 64 K-byte program in a machine with only 32 K bytes of memory).

Conclusions

- This book is physically very well designed for maximum use by programmers who want to understand the Level II ROM and add to the information provided in the book.
- The writing is uneven, sometimes clear enough for the novice, sometimes not.
- Despite its flaws of omission and the unevenness in the first chapters, the disassembly and its design make this one ROM book that everyone should buy.■

Two Short Graphics Programs for the OSI C-1P

John F Leahy
30345 Chualar Canyon Rd
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To speed up the action, use a delay limit of 500 or less. To slow it down, try 3000 or higher.

Happy viewing! ■

Listing 1: *This OSI BASIC program displays fascinating random graphics patterns on your video display.*

```
10 FOR X = 1 TO 30: ? : NEXT
20 INPUT"RISE TIME (1000?)"; E
30 INPUT"DECAY TIME (1500?)"; F
40 FOR X = 1 TO 30: ? : NEXT
50 C = INT (RND(1)*255)
60 D = 0
70 L = INT (RND(1)*920)
80 L = L + 53314
90 POKE L,C
100 D = D + 1
110 IF D > E THEN C = 32
120 IF D = F GOTO 50
130 GOTO 70
```

Listing 2: *A variation of the display program in listing 1.*

```
10 FOR X = 1 TO 30: ? : NEXT
20 INPUT"DECAY TIME (1500?)"; M
30 FOR X = 1 TO 30: ? : NEXT
40 I = INT (RND(1)*M)
50 C = INT (RND(1)*255)
60 L = INT (RND(1)*920)
70 L = L + 53314
80 POKE L,C
90 FOR T = 1 TO I: NEXT
100 POKE L,32
110 GOTO 40
```

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Memory Manipulator

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Under Radio Shack Level II BASIC, you can store short machine-code subroutines in string variables. The strings cannot be loaded via cassette, however, because several ASCII (American Standard Code for Information Interchange) codes will be interpreted as end characters and cause a loss of data. Therefore, the only way to use the strings as storage is to either POKE the code into memory or list it in the program as DATA elements, both of which require converting the data to decimal first.

Memory Manipulator is an attempt to solve that problem and the hassles of translating characters to ASCII codes, or any combination of hexadecimal, ASCII, or decimal conversion. It is an outgrowth of my intense dislike for errors that are due to base conversions creeping in and destroying what could have been a good program.

Program Operation

Memory Manipulator (see listing 1) allows you to input data in either hexadecimal, ASCII, or decimal, store the data at any location in programmable memory, and list it in any of the three forms on a video display or a line printer. Each function of the program is essentially independent of the other; the only routines shared are the hexadecimal-to-decimal conversion section at line 5000 and its reciprocal function at 6000. The remainder of the functions can be inserted or omitted as you see fit. The program uses about 3600 bytes of memory; however, this can be greatly reduced by deleting remarks and using multiple-statement program lines. There are not too many remarks, because the program is essentially self-explanatory.

Text continued on page 362

Listing 1: *Memory Manipulator program, written in Radio Shack Level II BASIC. This program takes data input as ASCII characters, decimal numbers, or hexadecimal numbers and places the hexadecimal equivalents into a specified area of memory. It also can read hexadecimal data from memory and display it in any of the above forms.*

```
10 'MEM MANIPULATOR
20 'BY LOUIS P. WITT,JR.
30 '
40 'THIS ROUTINE-
50 '     POKES & PEEKS IN
60 '              HEX
70 '              DECIMAL
80 '              ASCII
90 '     ALLOWS ALL ADDRESSES INPUT AS HEX
94 CLEAR 500
95 DEFSTR A-C
100 '
110 'MENU
120 CLS :PRINT CHR$(23)
125 PRINT:PRINT"
MEMORY MANIPULATOR
130 PRINT"1 HEX POKE
140 PRINT"2 HEX PEEK
150 PRINT"3 DEC POKE
160 PRINT"4 DEC PEEK
162 PRINT"5 ASC POKE
165 PRINT"6 ASC PEEK
170 PRINT:PRINT
180 INPUT"SELECTION";N
190 ON N GOTO 1000,2000,3000,4000,7000,8000
200 GOTO 120
1000 PRINT"POKE MEMORY
1010 INPUT"START WITH";X$
1020 GOSUB 5000 'CVRT TO DEC
```

Listing 1 continued on page 358

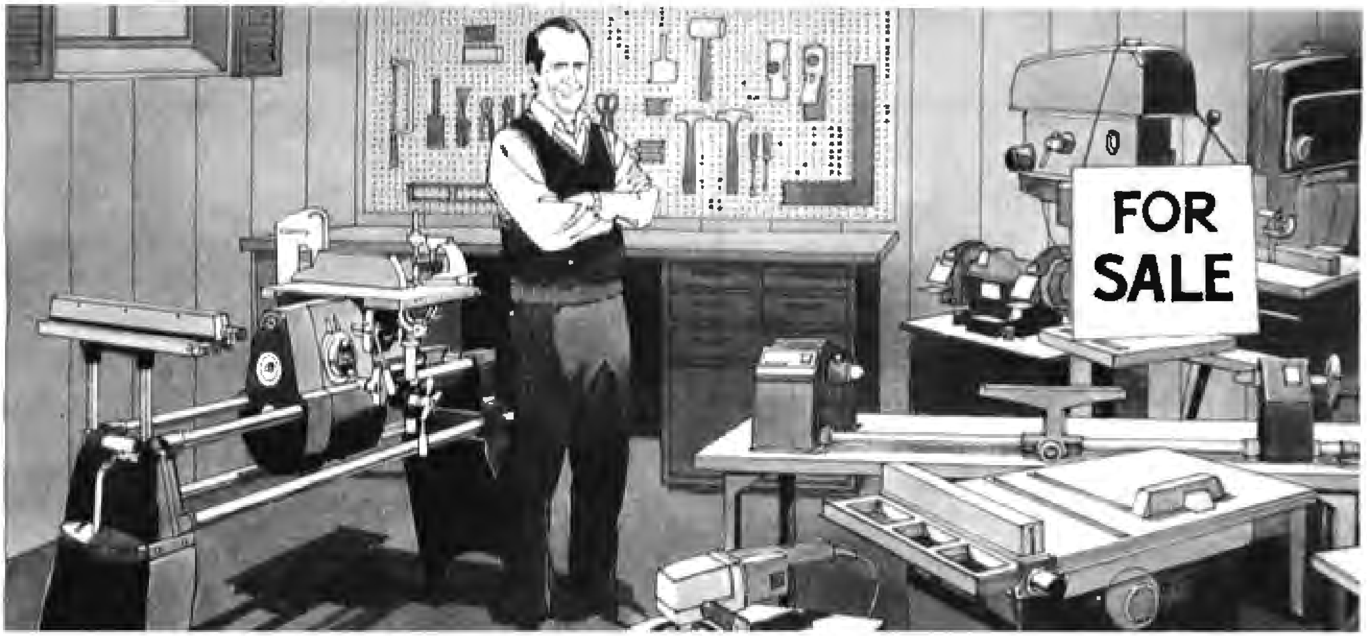




Listing 1 continued:

```
1030 N=X         'START WITH N
1040 X=N
1050 GOSUB 6000' CVRT TO HEX
1060 PRINT"MEM=>"X$;
1070 INPUTX$
1080 GOSUB 5000' CVRT TO DEC
1085 IF N>32767 THEN
      N=-1*(65536-N)
1090 POKE N,X    'STORE
1095 IF N<0 THEN
      N=65536+N
1100 N=N+1       'NEXT CELL
1110 GOTO 1040   'LOOP
1111 '
1112 '
1113 '
1114 '
2000 'READ MEMORY
2010 INPUT"1 FOR CRT
          2 FOR PRINTER";P
2020 INPUT"START AT";X$
2030 GOSUB 5000 'CVRT TO DEC
2040 N=X
2050 INPUT"END AT";X$
2060 GOSUB 5000 'CVRT TO DEC
2065 CLS
2070 FI=X
2080 FORN=N TO FI STEP 16
2090 X=N
2100 GOSUB 6000 'CVRT TO HEX
2110 PRINT X$"=>";
2115 IFP=2THENLPRINTX$"=>";
2120 FOR M=0 TO 15
2125 R=N+M : IF R>32767
      THEN R=-1*(65536-R)
2130 X=PEEK(R)
2140 GOSUB 6000 'CVRT TO HEX
2150 X$=RIGHT$(X$,2)
2160 PRINTX$;" ";
2170 IFP=2THEN LPRINTX$;" ";
2180 NEXT M
2185 PRINT
2187 IF P=2 THEN LPRINT" "
2190 NEXT N
2200 GOTO 120
2210 '
2211 '
2212 '
2213 '
2214 '
3000 PRINT"DECIMAL POKE MEMORY
3010 INPUT"START ADDRESS";X$
3020 GOSUB 5000 'CVRT DEC
3030 N=X
3040 X=N :GOSUB 6000
3050 PRINTX$;
3060 INPUTJ
3065 IF J>255 OR J<0 THEN 120
3070 R=N : IF R>32767 THEN
     R=-1*(65536-R)
3080 POKE R,J
3090 N=N+1
3091 '
3092 '
3093 '
3094 '
3100 GOTO 3040
4000 PRINT"DECIMAL PEEK MEMORY
```

Listing 1 continued on page 360



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Address ____________________

City ____________________

State ____________________ Zip ________

Programming Quickies

Listing 1 continued:

```
4010 INPUT"1 FOR CRT
            2 FOR PRINTER";P
4020 INPUT"START ADDRESS";X$
4030 GOSUB 5000 'CVRT DEC
4040 N=X
4050 INPUT"END ADDRESS";X$
4055 GOSUB 5000
4057 CLS
4060 FI=X
4070 FORN=N TO FI STEP 10
4080 X=N : GOSUB 6000
4090 PRINTX$"=>"
4100 IFP=2THENLPRINTX$"=>";
4110 FOR M=0 TO 10
4120 R=N+M :IF R>32767 THEN
     R=-1*(65536-R)
4130 PRINT USING " ### ";PEEK(R);
4140 IFP=2 THEN LPRINT USING
     " ### ";PEEK(R);
4150 NEXTM
4160 PRINT
4170 IFP=2THENLPRINT" "
4180 NEXT N
4190 INPUTZ$:GOTO120
4200 '
4210 '
4211 '
4212 '
4213 '
4214 '
5000 'X=DEC VALUE OF X$(HEX)
5010 X=0
5015 IF LEN(X$)=0 THEN 5120
5020 A1=LEFT$(X$,1)
5030 X1=ASC(A1)
5040 X1=X1-48
5050 IF X1>9 THEN X1=X1-7
5060 IF X1<0 OR X1>15 THEN 120
5070 X=X*16+X1
5090 X$=RIGHT$(X$,LEN(X$)-1)
5100 GOTO 5015
5120 RETURN
5130 '
5140 '
5141 '
5142 '
6000 'X$=HEX VALUE OF X
6010 X$=""
6020 FOR Q=3 TO 0 STEP -1
6030 X1=FIX (X/16[Q)
6040 X=X-X1*16[Q
6050 X1=X1+48
6060 IF X1>57 THEN X1=X1+7
6070 X$=X$+CHR$(X1)
6080 NEXT Q
6090 RETURN
6091 '
6092 '
6093 '
6094 '
7000 PRINT"ASCII POKE"
7010 INPUT"START ADDRESS";X$
7020 GOSUB 5000
7030 N=X
7040 X=N
7050 GOSUB 6000
7060 PRINTX$"=>";
7070 A=INKEY$:IFA=""THEN7070
```

Listing 1 continued on page 362

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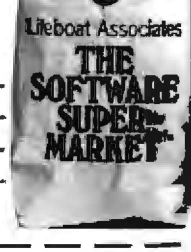
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Listing 1 continued:

```
7075 PRINTA
7080 R=N : IF R>32767 THEN
     R=-1*(65536-R)
7090 POKE R,ASC(A)
7100 N=N+1
7110 GOTO 7040
7111 '
7112 '
7113 '
7114 '
8000 PRINT"ASCII PEEK MEMORY
8010 INPUT"1 FOR CRT
          2 FOR PRINTER";P
8020 INPUT"START    ADDRESS";X$
8030 GOSUB 5000
8040 N=X
8050 INPUT"ENDING ADDRESS";X$
8060 GOSUB 5000
8070 FI=X
8080 FOR N=N TO FI STEP 16
8090 X=N : GOSUB 6000
8100 PRINTX$"=>";
8110 IF P=2 THEN LPRINTX$"=>";
8120 FORM=0 TO 15
8130 R=N+M : IF R>32767 THEN
     R=-1*(65536-R)
8140 J=PEEK(R)
8150 IF J<32 OR J>127 THEN
     J=46
8160 PRINT CHR$(J);"  ";
8170 IFP=2 THEN LPRINT CHR$(J);"  ";
8180 NEXT M
8190 PRINT
8200 IFP=2THEN LPRINT" "
8210 NEXT N
8220 INPUTZ$:GOTO 120
8221 END
8222 '
8223 '
8224 '
```

Text continued from page 356:

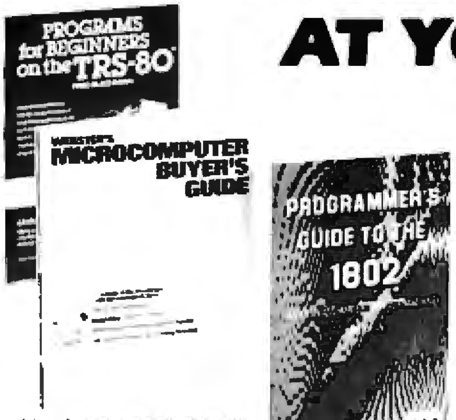
Under Level II BASIC, POKE and PEEK first convert their operands to 2-byte signed integers, having a range of −32768 to +32767. Since memory locations can go as high as 65535, this range would be inadequate. The sequence before the POKEs and PEEKs (such as line 1085 in listing 1) works out the integer value that will properly address the location you desire. If you're operating a 16 K-byte (or less) machine, you can omit these statements.

There are no formal exits from the loops in the program sections, so an intentional error or the BREAK key must be used. Usually this is bad practice, since rerunning the program will lose variables or leave a job half done. In this case, it is acceptable because arguments are not being passed from section to section.

Using the Program

Before you load this program, set aside some high memory by means of the MEMORY SIZE? parameter; otherwise, you can destroy the program as soon as you POKE anything into memory.

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If you use the program to convert a short routine to decimal so that you can place the converted codes into a data statement of another program, load the system tape containing the data to be converted and use the decimal PEEK function in listing 1. All addresses are given and returned in hexadecimal. If you want the addresses in decimal, replace the GOTO 5000 statements following the address input with:

```
N=VAL (X$)
```

Also, check inside the display loops for similar changes.

Memory Manipulator can be used to examine the contents of any section of memory. If you have a program in memory that works (ie: you already spent a night debugging it), you can use the hexadecimal PEEK function to get a hard copy of the code in memory. (See listing 2.) If you're ever searching for a particular routine in ROM (read-only memory), this function could be equally beneficial. To find the subroutine, insert a few lines into the program in listing 1 that will test the contents of the bytes it reads for the machine instruction you are looking for.

For example, if you want to find the routine in the Level II BASIC ROM that converts values to strings for display, change the print lines in the hexadecimal PEEK section so that it only prints when the next 3 bytes contain the numeric codes for a CALL 0033 Z80 instruction. This approach won't be fast and you'll have a lot of searching to do, but it beats rewriting a routine that's already in the machine.

This program was written with the intention of adding and changing the code as special situations arise, so make alterations freely.

Perhaps "hex-a-phobia" will be cured in short order! ■

Listing 2: *Sample outputs of the program in listing 1 showing the contents of memory locations hexadecimal 4A00 to 4AFF. Listing 2a shows the equivalent ASCII characters. Note that locations which contain codes not associated with printable ASCII characters are displayed as dots (.). Listings 2b and 2c show the decimal and hexadecimal equivalents, respectively.*

(2a)

```
4A00=>=  >  "  ;  .  .  J  .  .  .     M  .  @     .
4A10=>   1  0  .  ?  J  .  .  R  .  N  .  M     !  .
4A20=>   R  .  3  2  7  6  7        .  .
4A30=>R  .  .  1  .  (  6  5  5  3  6  .  R  )  .  U
4A40=>J  '  .  .     .     '     #  #  #     '  ;  .
4A50=>(  R  )  ;  .  W  J  ,  .  .  P  .  2     ,
4A60=>,     .  .              '     #  #  #     .
4A70=>;  .  (  R  )  ;  .  +  J  6  .  .  M  .  .  J
4A80=>8  .  .  .  .  J  J  .  .  P  .  2  .  .  "
4A90=>'  .  .  J  T  .  .     N  .  .  J  +  .  .  Z
4AA0=>$  :  .  1  2  0  .  .  J  h  .  :  .  .  .  .
4AB0=>J  T  .  [  .  .  .  .  J  .  .  :  .  .  .  .
4AC0=>J  t  .  ;  .  .  .  .  J  U  .  ]  .  .  .  .
4AD0=>J  v  .  ;  .  .  .  .  J  .  .  I  .  .  X  .
4AE0=>D  E  C     V  A  L  U  E     O  F     X  $  (
4AF0=>H  E  X  )  .  .  J  .  .  X  .  D  .  .  K  .
```

(2b)

```
4A00=>   61   62   34   59    0   20   74   14   16  129   32
4A0A=>   32   77  213   48   32  189   32   49   48    0   63
4A14=>   63   74   24   16   82  213   78  205   77   32   58
4A1E=>   58  143   32   82  212   51   50   55   54   55   32
4A28=>   32  202   10   32   32   32   32   32   82  213  206
4A32=>  206   49  207   40   54   53   53   51   54  206   82
4A3C=>   82   41    0   85   74   34   16  178   32  191   32
4A46=>   32   34   32   35   35   35   32   34   59  229   40
4A50=>   40   82   41   59    0  119   74   44   16  143   80
4A5A=>   80  213   50   32  202   32  175   32  191   10   32
4A64=>   32   32   32   32   32   34   32   35   35   35   32
4A6E=>   32   34   59  229   40   82   41   59    0  126   74
4A78=>   74   54   16  135   77    0  132   74   64   16  178
4A82=>  178    0  146   74   74   16  143   80  213   50  202
4A8C=>  202  175   34   32   34    0  154   74   84   16  135
4A96=>  135   32   78    0  167   74   94   16  137   90   36
4AA0=>   36   58  141   49   50   48    0  175   74  104   16
4AAA=>   16   58  147  251    0  183   74  114   16   58  147
4AB4=>  147  251    0  191   74  115   16   58  147  251    0
4ABE=>    0  199   74  116   16   58  147  251    0  207   74
4AC8=>   74  117   16   58  147  251    0  215   74  118   16
4AD2=>   16   58  147  251    8  245   74  136   19   58  147
4ADC=>  147  251   88   61   68   69   67   32   86   65   76
4AE6=>   76   85   69   32   79   70   32   88   36   40   72
4AF0=>   72   69   88   41    0  253   74  146   19   88  213
```

(2c)

```
4A00=>3D 3E 22 3B 00 14 4A 0E 10 81 20 4D D5 30 20 BD
4A10=>20 31 30 00 3F 4A 18 10 52 D5 4E CD 4D 20 3A 8F
4A20=>20 52 D4 33 32 37 36 37 20 CA 0A 20 20 20 20 20
4A30=>52 D5 CE 31 CF 28 36 35 35 33 36 CE 52 29 00 55
4A40=>4A 22 10 B2 20 BF 20 22 20 23 23 23 20 22 3B E5
4A50=>28 52 29 3B 00 77 4A 2C 10 8F 50 D5 32 20 CA 20
4A60=>AF 20 BF 0A 20 20 20 20 20 22 20 23 23 23 20 22
4A70=>3B E5 28 52 29 3B 00 7E 4A 36 10 87 4D 00 84 4A
4A80=>40 10 B2 00 92 4A 4A 10 BF 50 D5 32 CA AF 22 20
4A90=>22 00 9A 4A 54 10 87 20 4E 00 A7 4A 5E 10 87 5A
4AA0=>24 3A 8D 31 32 30 00 AF 4A 68 10 3A 93 FB 00 B7
4AB0=>4A 72 10 3A 93 FB 00 BF 4A 73 10 3A 93 FB 00 C7
4AC0=>4A 74 10 3A 93 FB 00 CF 4A 75 10 3A 93 FB 00 D7
4AD0=>4A 76 10 3A 93 FB 00 F5 4A 88 13 3A 93 FB 58 3D
4AE0=>44 45 43 20 56 41 4C 55 45 20 4F 46 20 58 24 28
4AF0=>48 45 58 29 00 FD 4A 92 13 58 D5 30 00 12 4B 97
```

Use a Relative Subroutine Call for Relocatable Z80 Programs

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Hawaii Institute of Marine Biology
POB 1346
University of Hawaii at Manoa, Coconut Island
Kaneohe HI 96744

Zilog's Z80 microprocessor has many improvements over its predecessor, the Intel 8080A microprocessor. One nagging difficulty, however, is the lack of higher-level languages that take full advantage of the Z80 operation codes. If you want complete control of its capabilities, assembly-language or machine-executable object-code programming is a must.

In machine language, there are methods of writing relocatable programs that use a patched routine for accomplishing calls to subroutines. These methods are valuable for fast interrupt servicing and similar applications, especially when programs are in modular form but not residing in specific memory locations.

Although the Z80's operation-code set is well suited to my needs, I grew frustrated when I found more and more applications for my microcomputer. Suddenly, the EPROM- (erasable programmable read-only memory) based program residing at hexadecimal addresses E400 through E5FF had to be moved to E800 through E9FF. All would have been well if the EPROM's software had used the six *relative-jump* operation codes. The program was relocatable, however, because it didn't contain any references to specific (absolute) addresses.

Many programs can be written without using jump and call instructions that cannot be relocated. However, if many portions of your program demand the use of a similar set of instructions, such as querying an output device or performing arithmetic manipulation, the headaches begin. Such programs should usually be written in a modular form with a main program that jumps back and forth to frequently used subroutines.

Modular programs use *call* instructions to access the subroutines. Since the call instruction contains the absolute address of the subroutine (using immediate external addressing), the code is not relocatable without changing all of the subroutine-call addresses. The general philosophy of modular programming with a main program that calls a variety of subroutines is certainly sound. (See the article by James Lewis, "Some Notes on Modular Assembly Programming," December 1979 BYTE, page 222.) A glance at the operation-code listings for powerful software such as the Cromemco Resident Monitor reveals a bewildering jungle of subroutine calls that pack an impressive set of capabilities into a 1 K-byte chip. But if you decide to locate this monitor anywhere

except the intended address range of hexadecimal E000 through E3FF, sharpen your wits and your pencil, and best of luck to you. There are more than just a few immediate-external address references to change.

To explore this dilemma further, it is important to understand three basic differences between a *relative jump* and a *call* in the Z80 instruction set. First, the relative jump is a 2-byte instruction that requires from seven to twelve external clock cycles for fetching and execution, while the call instruction demands 3 bytes and ten to seventeen clock cycles. (Score a few points for the relative jump for saving 1 byte of programming space and 1 to 2 microseconds, at 4 MHz.)

Second, the relative jump leaps to the same point in the *program* regardless of where the program resides in memory, because the jump is made relative to the current value of the *program counter*. In contrast, the call instruction includes a 2-byte address for the jump destination, which will obviously be wrong if the program is moved to another region of memory. Whenever the program is moved, the 2-byte address must be changed. (Score a pile of points for the relative jump.)

Third, alas, the ignorant subroutine that is accessed via a relative jump has no idea how to return to the proper location if it is accessed from more than one place in the main program. The call instruction includes an "intelligent return" that lets the subroutine jump right back to the next instruction following the call. (Don't despair, save those relative-jump points for later.)

Dennis Kitsz suggested a simple solution to this problem that is fast and requires only a few bytes more than a standard subroutine. (See "Relative Subroutines for the Z80," December 1979 BYTE, page 87.) The only restrictions to its use are that the program cannot reside in ROM (read-only memory), and each time the program is moved, a single 2-byte address in the program must be changed. [*Also, most programmers prefer to avoid self-modifying code. . . .* RSS] However, besides the restriction to programmable memory, an error in the calculation of the 2-byte address can destroy the program.

There is another method, which I'll explain shortly, that is more complex but works in ROM and needs no changes when the program is moved.

The intelligent return is allowed because the call instruction accomplishes one task that cannot be accomplished by any of the other Z80 operation codes: a subroutine call pushes the value of the program counter onto the stack while the return from the subroutine pops it back. The program counter is, of course, the register that tells the Z80 the address for the next instruction to be fetched. If only you could take a peek or push at the program counter before executing a relative jump, the *relative call* would be born. A relative-called subroutine could make an intelligent return to the main program, and the modular program would have relocatable code. Unfortunately, for some undoubtedly sound reason, one

cannot directly push from, pop to, or otherwise gain direct access to the program counter in the Z80 microprocessor.

If you can stand a few sacrifices, I found that the Z80 can be coerced to make a relative call. First, the fastest and most direct method for implementing a relative call demands that 5 bytes of page-zero programmable memory, beginning at one of the eight restart locations accessed with the Z80's RST instruction (hexadecimal 0000, 0008, 0010, 0018, 0020, 0028, 0030, or 0038), be available for storage of a routine that gains access to the program counter. Second, each relative call must have a 3-byte instruction code, while the actual fetching and execution of the call will require seventy-one to seventy-six external clock cycles. This means that, at a 4 MHz clock rate, a relative call will take around 15 microseconds longer than a normal subroutine call. Third, return from the subroutine must be unconditional, but it will require only four external clock cycles instead of the ten required to return from a normal call. Fourth, the HL register pair must be available for use during the relative call to the subroutine.

The trick is to use the single-byte RST (*restart*) instruction as the call instruction. A restart forces a jump to a 5-byte routine in page zero of memory, and pushes the program counter onto the stack where it is accessible. While you have the program counter's contents cornered on the stack, the 5 bytes of instructions in page zero are used to copy it into an accessible register pair and increment it to point to the instruction immediately following the relative call. You then return from page zero to the main program and execute the relative call. "Intelligent return" from the subroutine is accomplished by a jump to the address indicated by the register pair in which you stored the value of the program counter at the time the RST was encountered.

A simple example is given in listing 1. The 5-byte routine is stored in page zero from hexadecimal 0008 to 000C. The relocatable program code is located in a space around address hexadecimal 0F00. The HL register pair is used to store the return address for the relative call.

The first relative call begins at hexadecimal 0F00 with an RST 8 instruction, which pushes the program counter onto the stack and jumps to hexadecimal 0008. The stored value of the program counter (hexadecimal 0F01) is copied into HL with the pop- and push-stack operations. It is then incremented to point to the instruction following the relative call (hexadecimal 0F03). Execution returns to the relative jump at hexadecimal 0F01. A relative jump is made to the subroutine at location 0F50. At the end of the subroutine, an "intelligent return" is made to location 0F03 by jumping to the address contained in register HL (JP (HL), a *register-indirect jump*). When the same subroutine is relative-called by the instructions at addresses hexadecimal 0F20 through 0F22, the same sequence occurs except that the address register,

HL, will contain a different return address, 0F23. The same instruction at the end of the subroutine returns to the main program at 0F23.

The simplest method of creating the relative call is to store the 5-byte routine in page zero by using a 17-byte initialization routine, shown here as listing 2, at the beginning of the main program. It only needs to be executed once, so long as you do not overwrite its storage area.

There are many variations on this theme. Most notably, any of the conditional relative jumps may be used, including the Z80's loop-implementing jump instruction, DJNZ. More important, some systems may require modification of the basic technique. For example, if the HL register is busy or must be used to pass information to the subroutine, the 3-byte relative-call instruction could be expanded to 5 bytes by adding the EXX instruction (register-set exchange, Z80 op code D9) *before and after* the RST 8 instruction, *and* before the intelligent return instruction (JP (HL), Z80 op code E9) in the subroutine, *and* after the relative-jump portion of the relative call. The relative-call sequence in listing 1, for example, would become 3 bytes longer (D9 CF D9 18 4D D9) while the return from the relative call would become 1 byte longer (D9 E9). Note that if this technique is used for any relative call to a subroutine, it *must* be used for *all* relative calls to *that* subroutine, since the subroutine now contains a register-exchange instruction.

If the complementary sets of registers, HL and HL', are both unavailable, as in an interrupt-servicing program, the IX or the IY index registers could be used. However, incrementing, pushing, and popping these registers requires still more bytes of instructions and more time to execute.

Another interesting possibility exists if you are unable to use page-zero programmable memory. You could, of course, replace the RST instruction with a 3-byte call instruction to some other idle memory location. But idle locations have a habit of not remaining idle as your applications evolve. However, if you already have a nonrelocatable ROM program, such as a resident monitor, it may be possible to find a 5-byte space that you can steal as a permanent storage location for the 5 bytes formerly placed in page zero. You then have the program merely execute a 3-byte call instruction to that address rather than execute the 1-byte RST instruction.

Listing 1: *Sample implementation of the relative-call (relocatable-subroutine call) function on a Z80-based system. Instead of using the normal subroutine-call instruction, subroutines are accessed with a RST (reset) and a relative jump. The RST calls a routine in low memory that sets up the return address by placing the proper return address in the HL register pair. This initialization routine then returns to the relative-jump instruction immediately following the RST. The RST jumps to the actual subroutine being called. At the end of each subroutine, a normal return is emulated with a jump to the address contained in the HL register.*

```
             Hexadecimal  Object  Instruction
             Address      Code    Mnemonic     Comment

Page Zero
             0008         E1      POP HL       ; copy PC (program counter) into HL
             0009         E5      PUSH HL
             000A         23      INC HL       ; increment HL to point to subroutine
                                                 return address
             000B         23      INC HL
             000C         C9      RET          ; return to the relative call
             .
             .
             .
Relocatable Program
  Main Program
             .
             0F00         CF      RST 8        ; call page-zero "peek" at PC
             0F01         18 4D   JR +4D       ; execute "relative call"
             0F03         (sequence of instructions)
             .
             .
             0F20         CF      RST 8        ; call page-zero "peek" at PC
             0F21         18 2D   JR +2D       ; execute "relative call"
             0F23         (sequence of instructions)
             .
             .
  Subroutine
             .
             0F50         (sequence of instructions)  ; start of subroutine
             .
             .
             ????         E9      JP (HL)      ; return from relative call
```

Listing 2: *Program to set up the 5-byte initialization routine in low memory (hexadecimal location 0008, in this example).*

Hexadecimal Address	Object Code	Instruction Mnemonic	Comment
N	21 08 00	LD HL, 0008	; load page-zero call pointer
N+3	36 E1	LD (HL), E1	; load 5-byte string into page zero of memory
N+5	23	INC HL	
N+6	36 E5	LD (HL), E5	
N+8	23	INC HL	
N+9	36 23	LD (HL), 23	
N+B	23	INC HL	
N+C	36 23	LD (HL), 23	
N+E	23	INC HL	
N+F	36 C9	LD (HL), C9	

For example, one version of the Cromemco Resident Monitor includes a string of ASCII (American Standard Code for Information Interchange) characters stored to provide a header output, beginning at hexadecimal location E3F0. I really don't care whether the header says "CROMEMCO ZM1." or "HOWDY" or "%@$$". This is a convenient space to stick the 5 bytes from page zero so long as I am careful to change any other features of the monitor that refer to this string before programming the EPROM. For my purposes, I can merely shift the whole string 5 bytes backwards so that I lose two carriage returns and "CRO". The 5-byte routine from page zero can then begin at E3FB.

Do be careful if you try this sort of thing. Don't erase your old EPROM until you are certain your modification works. Another version of the same monitor has a string of spare bytes (containing hexadecimal character FF) from address E3F5 to E3FF. Inasmuch as any character can be written over an FF on an EPROM, the 5-byte code can be programmed directly onto the chip containing the code without altering the monitor in any way. Of course, once the 5 bytes are firmly installed in ROM, you can forget the nuisance of having to use the 17-byte initialization routine in listing 2. Merely rewrite your instruction-code manual to list the op codes for your newly created relative-call and return-from-relative-call instructions. ■

BASIC, Pascal, or Tiny-c?
A Simple Benchmarking Comparison

Phil Hughes, POB 2847, Olympia WA 98507

Three of the most popular high-level languages for microcomputers are BASIC, Pascal, and tiny-c. I developed a card-shuffling program in each of these languages, and my experience should help you select the language for your needs.

One way of stating the card-shuffling algorithm is: "Store and print the integers from 0 through 51 in a random sequence." To ensure that the programs perform equivalent functions, I added the following conditions:

- The result is to be printed with ten integers per line.
- Following the result, the message "ALL DONE!" is to be printed on a new line.
- The algorithm is to get a random number, check to see if it has already been used, and if not, the number is to be stored. The sequence is to be repeated until fifty-two numbers have been generated.
- The shuffling procedure must be implemented as a subroutine, and it must be reusable.

Experts or fans of each language could argue with my conditions, saying that they are prejudicial in favor of a certain language. That was not my intent.

I began by looking at the shuffling routine in a Blackjack game that a friend was playing. Its method was to keep a list of the used cards and generate a new card each time there was a draw. At this time, the new card was added to the used list. When the used-card list was full, a reshuffle, which consisted of clearing the used list, was forced.

I wondered how long it would take to perform the shuffle by selecting all the cards at one time and storing them in an array. This method seemed closer to what you do with an actual deck of cards.

I had been working on a tiny-c interpreter, so I decided to code my idea first in tiny-c. Because of tiny-c's long execution time, I then tried my algorithm in Pascal. Finally, I wrote a BASIC version to complete the comparison.

An important factor in this comparison is my experience with each language. I learned BASIC in 1970 as part of my job, and I have used it for development of quick programs for large-computer systems ever since. I have used various BASIC interpreters on microcomputers for the past three years. I have developed a tiny-c interpreter, but I have actually written only two tiny-c programs, each about thirty lines long. I have written three or four short Pascal programs. Armed with this information, decide for yourself which language you would use for a given set of conditions and a given problem.

Tiny-c Coding

Listing 1 is the tiny-c program, and listing 2 is the result of executing the program. The first nine lines of the program listing are a (pseudo) random-number generator. This routine appeared in the *Tiny-c Owner's Manual* (available from Tiny-c Associates). Although this can be

Listing 1: *The card-shuffling routine coded in the tiny-c language. The first nine lines of source code generate pseudorandom numbers. The actual shuffling algorithm is coded beginning with the line starting with "shuffle".*

```
int seed,last
random int little,big[
int range
if(last==0)seed=last=99
range=big-little+1
last=last*seed
if(last<0)last=-last
return little+(last/8)%range
]
int cards(51)
shuffle[int current;current=0
int temp,i
  while (current<52)[
    i=0
    temp=random(0,51)
    while (i<current)[
      if(cards(i)==temp) break
      i=i+1
      ]
    if(i==current)[
      cards(current)=temp
      current=current+1
      ]
    ]
return
  ]
test[
shuffle
int i;i=0
while (i<52)[
  pn cards(i)
  i=i+1
  if(i%10==0)pl""
  ]
pl"all done!"
]
```

Listing 2: *Sample execution of the tiny-c program of listing 1.*

```
.test
29 32 45 21 51 10 12 24 39 25
22 50 30 1 19 46 44 37 20 26
18 28 34 7 3 49 0 42 27 14
35 13 4 41 6 31 43 23 38 33
40 36 48 8 5 2 16 9 11 17
47 15
all done!
>
```

thought of as a library function, I decided to include it in the program. The next seventeen lines are the "shuffle" routine. Finally, the last ten lines (starting with "test[") are the main program that calls "shuffle" and prints the result.

It was easy to go from the design to the actual tiny-c program. It took ten minutes to code the program and another fifteen minutes to enter it and get it running. My biggest problem with tiny-c is remembering that == is the relational operator for equality. That mistake cost me a few minutes of debugging time.

Pascal Coding

Listings 3 and 4 show the Pascal program and its execution. Pascal does not have a built-in random-number generator. I borrowed ideas from the sample programs that come with the Lucidata Pascal compiler to code the function RANDOM in listing 3. The only difficult part of the

Listing 3: *The card-shuffling routine coded in Lucidata Pascal. An explicit random-number-generating function is used here, as in tiny-c.*

```
PASCAL P-COMPILER  ( VERSION 2 )   : COPYRIGHT C 1980 D.R.GIBBY
   0 PROGRAM TEST;(* Shuffle cards and print result *)
   0 VAR
   0   CARDS : ARRAY[1..52] OF INTEGER;
   0   I : INTEGER;
   0   SEED : INTEGER;
   0 PROCEDURE SHUFFLE;
   4   VAR
   4     CURRENT,TEMP,I : INTEGER;
   4   FUNCTION RANDOM(LITTLE,BIG : INTEGER) : INTEGER;
   8     VAR
   8       RANGE : INTEGER;
   8     BEGIN
  12       IF(SEED=0) THEN SEED:=99;
  32       RANGE:=BIG-LITTLE+1;
  52       SEED:=SEED*31;
  64       SEED:=SEED MOD 1009;
  76       RANDOM:=LITTLE+SEED MOD RANGE;
 100     END;
 104   BEGIN
 108     CURRENT:=1;
 116     REPEAT
 116       I:=1;
 124       TEMP:=RANDOM(1,52);
 144       WHILE ((CARDS[I]<>TEMP) AND (I<CURRENT)) DO I:=I+1;
 196       IF (I=CURRENT) THEN BEGIN
 208         CARDS[CURRENT]:=TEMP;
 224         CURRENT:=CURRENT+1;
 236       END;
 236     UNTIL (CURRENT=53);
 248  END;
 252 BEGIN (* MAIN PGM *)
 256   SEED:=0;
 264   SHUFFLE;
 268   FOR I :=1 TO 52 DO BEGIN
 288     WRITE (CARDS[I]);
 304     IF ((I MOD 10)=0) THEN WRITELN;
 324   END;
 344   WRITELN;
 348   WRITELN ("ALL DONE!");
 368 END.
```





Listing 4: *Sample execution of the Pascal program of listing 3.*

```
+++RUN,SHUFFLE

 P-6800  RUN-TIME  SYSTEM  V 1.2   : COPYRIGHT C 1978 LUCIDATA
 USABLE CONTIGUOUS MEMORY  $8000
 DEFAULT STACK RESERVATION $1000
 CHANGE VALUE ?

    43    34     3    11    30    52     1     8    17    45
    31    15    27     4    36    33    23    12    25    22
    21     7    51    37    44    18    26    10    38    41
     5    32     2     6    42     9    46    24    13    40
    29    39    47    14    28    16    50    48    49    20
    35    19
ALL DONE!

 END OF PROGRAM EXECUTION.
+++
```

conversion from tiny-c to Pascal was deciding how to do the equivalent operation of the tiny-c "break" keyword. ("Break" signifies that the innermost "while" loop is to be terminated immediately.) This was implemented in Pascal as part of the WHILE condition.

The development and testing of the Pascal program took about one hour, plus the time necessary to develop the RANDOM function. Much of this time was attributable to Pascal's being a compiled language. This made it necessary for me to use a text editor separate from the language system to make program changes. The biggest problem I have with Pascal's grammar is remembering that := is the assignment operator.

BASIC Coding

Finally, listings 5 and 6 are the BASIC version of the shuffling program and the execution results. BASIC had the advantage of its built-in random-number function,

Listing 5: *The card-shuffling routine coded in TSC BASIC. The built-in RND random-number function is used.*

```
50 DIM C(51)
100 GOSUB 1000
200 FOR I=0 TO 51
210 PRINT C(I);
220 IF INT((I+1)/10)=(I+1)/10 THEN PRINT
230 NEXT I
240 PRINT
250 PRINT "ALL DONE!"
300 END
1000 J=0
1010 T=INT(RND(0)*52)
1020 IF J=0 THEN 1060
1030 FOR I=0 TO J-1
1040 IF C(I)=T THEN 1010
1050 NEXT I
1060 C(J)=T
1070 J=J+1
1080 IF J<52 THEN 1010
1090 RETURN
```

Listing 6: *Sample execution of the BASIC program of listing 5.*

```
READY

RUN

 27  31  26  48  9  0  36  15  2  17
 40  49  39  29  51  1  3  30  6  44
 50  5  35  20  18  19  46  28  37  10
 24  16  4  14  47  25  7  8  12  42
 38  22  34  21  23  13  11  45  43  41
 32  33
ALL DONE!
```


which made the program appear much smaller and helped out the execution time. The first part of the program is the main routine. Lines 1000 through 1090 are the shuffling subroutine. It took thirty minutes to develop and test this program. The hardest part was converting the hierarchical structure of the shuffling subroutine into the available control structures of BASIC. This resulted in a FOR...NEXT loop and three IF statements.

Table 1 shows the execution times of each of these programs on a Southwest Technical Products Corporation 6800 system with a 1 MHz system clock rate. Note that Pascal is compiled, with the compilation process taking about thirty seconds. Table 2 shows the vendors for the three language systems.

Conclusions

Tiny-c is an easy-to-work-with language that supports structured programming. The source-code interpreter is extremely slow compared with a fast BASIC interpreter, but offers features such as long variable names and structured constructs. These capabilities make debugging easy. Also, tiny-c is easy to learn. A tiny-c interpreter for program development and a compiler for generating production programs would be an effective combination.

Pascal offers the structured constructs of tiny-c and much more. The execution speed of a compiled Pascal program is fast. The price you pay for this is a complicated language that is considered by many to be difficult for a beginner to learn. The complexity of Pascal makes availability of a source-code interpreter unlikely (although a source-code interpreter for a subset of Pascal is certainly possible). The complexity of full Pascal increases development time, but once created, a Pascal program is efficient and relatively easy to understand.

BASIC offers what initially appears to be the shortest program. However, on closer inspection of the tiny-c program, I found the following. If you were to remove the random-number function from the tiny-c program (and put it in the tiny-c function library) and move all the compound statement-delimiter brackets to the same lines as their preceding statements, the tiny-c and BASIC programs would have the same number of lines. The main problems with BASIC (at least of most dialects) are its lack of long variable names and hierarchical control constructs. These two deficiencies make the BASIC program difficult to understand.

In spite of the individual problems with these languages, each has its place. I hope that I have helped you select the language that best fits your needs. ■

Language	Execution Time
Tiny-c Version 1.1	160 seconds
Lucidata Pascal Version 2.2	16 seconds
TSC Extended BASIC	23 seconds

Table 1: *Comparison of execution times for the card-shuffling routine coded in three high-level languages.*

Language System	Vendor
Pascal	Lucidata Ltd, POB 128, Cambridge, CB2 5EZ, England
Tiny-c	Tiny-c Associates, POB 269, Holmdel NJ 07733
BASIC	TSC (Technical Systems Consultants), POB 2570, West Lafayette IN 47906

Table 2: *Companies selling the three language systems compared here.*

BYTE's Bits

Scholarship Competition Under Way

The fourth annual International Computer Programs (ICP) Scholarship award competition for college and university computer science and computer technology students is under way. The ICP award covers one year's tuition plus expenses to an American college or university of the winner's choice, up to a maximum of $5000.

Selection of the award is based on the student's cumulative grade-point average in his or her field of study, overall grade-point average, need for financial aid, participation in data processing- and school-related activities, leadership ability, and accomplishments and awards. Also, finalists will be asked to submit a written essay.

Applications for the competition are available at most financial aid departments. To qualify, applicants must be either sophomores or juniors pursuing an undergraduate degree and matriculated in a computer science or technology program at an American college or university. Deadline for filing applications is November 15, 1981.

For more information, contact Sheila Cunningham, Scholarship Director, ICP, 9000 Keystone Crossing, Indianapolis IN 46240, (317) 844-7461.

Literary Text Project

The Literary Text Project is a nonprofit, voluntary effort by a group of scholars to establish a computerized system of custom publishing works of English literature.

The scholars perceived that conventional publishers were not keeping in print low-cost selections of many poems written from 1660 to 1800, so they created a data base containing the text of poems. Users can order from a catalog printed copies of any poem in the data base, or any selection of several poems, thus creating a customized anthology.

As of April 1981, 150 titles by major and minor poets were available through the system. The works of Alexander Pope and William Blake are excluded from the list because of their wide availability. Plans are under way to expand the collection and the project into other kinds of literature and other fields.

Voluntary editorial efforts, advice, and inquiries are solicited. Contact Literary Text Project, c/o Dr Stephen Ackerman, 136 North Carolina Ave SE, Washington DC 20003. ■

A Fast, Ancient Method for Multiplication

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There are several ancient algorithms that adapt surprisingly well to the computer. One such example is the "Russian Peasant Method" for multiplication, which was discovered by Western visitors to Russia in the nineteenth century. However, the method is actually much older than that. It was used by Egyptian mathematicians as early as 1800 BC, although it was not stated as a completely systematic algorithm.

To explain this method, let A and B denote two numbers. A can be any number, while B must be a nonnegative integer. The problem is to calculate their product P. The method is:

1. Let $P = 0$
2. If B is odd, let $P = P + A$
3. Let $A = A + A$
4. Let B = integer part of $B/2$
5. If B is nonzero, repeat from step 2; otherwise the algorithm terminates.

An example will clarify how this works. Here are successive values of A and B, when their initial values are 175 and 18:

A:	175	350	700	1400	2800	5600
B:	18	9	4	2	1	0

Adding those As for which the corresponding Bs are odd, we have:

$$P = 350 + 2800 = 3150$$

which is the required result of 175 times 18. You may wish to try more examples to convince yourself that this procedure works correctly.

Notice that if A and B are unsigned integers expressed in binary, the doubling of A in step 3 can be performed by a left shift of A. Finding the integer part of $B/2$ in step 4 corresponds to a right shift of B. Furthermore, the B in step 2 is odd if its least-significant bit is 1.

Listing 1 shows a relocatable subroutine written in 6502 assembly language; also included is the hexadecimal object code. When the subroutine is entered, it is assumed that the low- and high-order bytes of A are found at memory locations 0000 and 0001 (hexadecimal), respectively. The low- and high-order bytes of B are found at locations 0002 and 0003, respectively. When the end of the subroutine is reached, locations 0004 and 0005 will contain the product P. If needed, the routine can be made shorter and faster by using the index registers (X and Y) for the product, instead of memory locations.

It is assumed here that P does not exceed 16 bits. If three or four bytes are required, it's relatively easy to expand the subroutine.

Multiplication routines similar to the one in listing 1 are found in arithmetic software and are coded in various languages. This does not mean that the routines' inventors were intentionally using the Russian Peasant Method. Probably, they were just imitating the familiar pencil-and-paper method for multiplication. As a matter of fact, when the numbers involved are binary and the algorithms are executed using the same instruction set, these two methods are identical.

A multiplication routine that looks slightly different, listing 1b, is often shown in microprocessor and microcomputer manuals. As a rule, this method should not be used. The loop starting at HALF is always entered sixteen times. Thus, the looping can continue to no purpose after B reaches 0.

The Russian Peasant Method can be modified to per-

form exponentiation. By setting P equal to 1 in step 1 and changing the addition in steps 2 and 3 to multiplication, the resulting value of P will be A raised to the power of B. Of course, steps 2 and 3 now assume that a multiplication routine is available. This method for exponentiation was stated by a Persian mathematician in the year 1414. ■

Reference

1. Knuth, D E. *The Art of Computer Programming,* Vol 2. Reading MA: Addison-Wesley, 1969. Pages 399 and 400.

Listing 1: *Relocatable subroutines for fast integer arithmetic on the MOS Technology 6502 microprocessor. Listing 1a shows a machine-language routine for multiplication by the Russian Peasant Method; listing 1b gives a version seen frequently in textbooks.*

(1a)

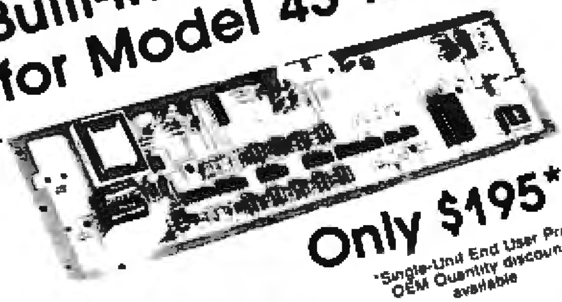
```
Object
 Code     Label     Mnemonic

A9  00    MULT      LDA    #0
85  04              STA    PLOW
85  05              STA    PHIGH
46  03    HALF      LSR    BHIGH
66  02              ROR    BLOW
90  0D              BCC    DOUBLE
18                  CLC
A5  04              LDA    PLOW
65  00              ADC    ALOW
85  04              STA    PLOW
A5  05              LDA    PHIGH
65  01              ADC    AHIGH
85  05              STA    PHIGH
06  00    DOUBLE    ASL    ALOW
26  01              ROL    AHIGH
A5  02              LDA    BLOW
05  03              ORA    BHIGH
D0  E3              BNE    HALF
60                  RTS
```

(1b)

```
Object
 Code     Label     Mnemonic

A9  00    MULT      LDA    #0
85  04              STA    PLOW
85  05              STA    PHIGH
A2  10              LDX    #$10
46  03    HALF      LSR    BHIGH
66  02              ROR    BLOW
90  0D              BCC    DOUBLE
18                  CLC
A5  04              LDA    PLOW
65  00              ADC    ALOW
85  04              STA    PLOW
A5  05              LDA    PHIGH
65  01              ADC    AHIGH
85  05              STA    PHIGH
06  00    DOUBLE    ASL    ALOW
26  01              ROL    AHIGH
CA                  DEX
D0  E6              BNE    HALF
60                  RTS
```

Integral Data's Paper Tiger 460

Eliakim Willner, datatronics inc, 675 Third Ave, New York NY 10017

Until very recently, a prospective purchaser of a computer printer had to choose between letter quality and speed. The letter-quality printers, which most often use daisy-wheels to produce fully formed characters, are too slow for typical data-processing applications. Faster printers usually employ a dot-matrix print head that produces readable, but not letter-quality, type.

A new breed of printer on the market today shows refinements in dot-matrix technology, producing type that approaches letter quality without sacrificing speed. Integral Data Systems' 460, the "Paper Tiger," is a worthy representative of this new breed. With minor exceptions, the IDS 460 has every feature that a hobbyist or small-business user could reasonably expect to find.

The printer is about as wide as most in the dot-matrix family, but it is taller and not as deep. It appears to be solidly constructed and designed to withstand heavy use. Most of the electronics, including a microprocessor to control the many advanced functions, are contained on a single, easily accessible circuit board under the printer's enclosure.

The enclosure is made of durable structural foam and has a pleasing look. Most of the controls are conveniently placed. On the upper right-hand side of the printer are a formset/online/offline switch and a formfeed/linefeed switch (see photo 1). The IDS 460 also has a self-test switch on the upper left-hand side which generates a repetitive test pattern. (Upon power-up, a diagnostic routine automatically clears the buffer and tests the printer's memory.) Next to the self-test switch are two DIP (dual-inline package) switches placed so that it is easy to change their settings deliberately, but difficult to do so accidentally. These switches are used for selecting many of the printing options that will be discussed shortly.

The IDS 460 has indicators for power-on, online, and fault. The fault indicator flashes when the power-up diagnostic encounters a hardware problem and lights when the printer runs out of paper.

Under the cover is a knob that moves the print-head mechanism back and forth, thus varying print intensity. This is useful for accommodating changing paper thickness. When printing thick labels, for example, the print head can be moved further back from the ribbon, saving wear on the head without affecting the quality of the print.

Unfortunately, this control is not easy to use. The knob is not calibrated, so trial and error is required to get

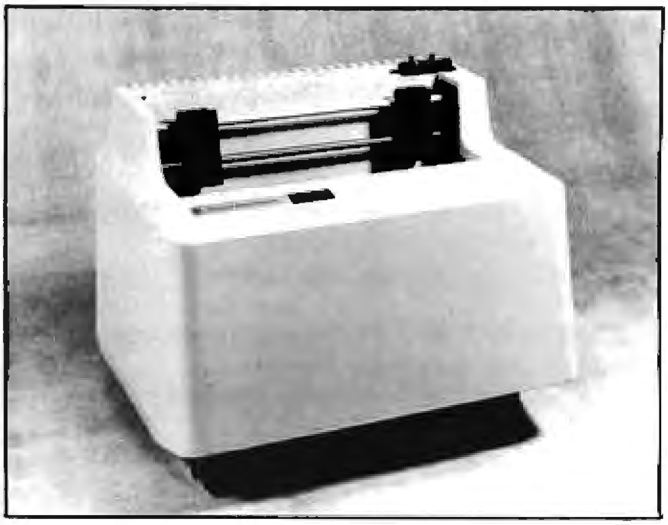


Photo 1: *The Integral Data Systems' Model 460 dot-matrix printer, better known as the Paper Tiger. At the upper right are the formset/online/offline switch and the formfeed/linefeed switch.*

the correct print intensity. If only one kind of form is to be used, this adjustment need only be done once. If the form is changed frequently, however, the constant readjustment can be inconvenient.

Still more inconvenient is the fact that this knob is placed beneath the printer enclosure. The enclosure is secured to the chassis with four knurled retainer nuts. To remove the enclosure the nuts are loosened and the enclosure is lifted directly upwards. There is little clearance between the enclosure and the chassis. Invariably the enclosure rubs against the circuit board or the tractor mechanism, or snags the ribbon. The knob for varying print intensity should certainly have been placed outside the enclosure.

Other controls are placed underneath the enclosure. These include the 115/220 V switch and various jumpers used to select the desired interface, but these are used infrequently.

Two secure tractors move paper through the IDS 460. There is no problem handling thick labels or multiple-part forms. Fanfold or roll paper up to ten inches wide may be used. (The IDS 560 is similar in many respects to the 460, but it accommodates paper up to fourteen inches wide.) An internal paper-roll holder that fits under the enclosure is available as an option, as is a paper-catch

At a Glance

Name
Paper Tiger 460

Use
High-speed, correspondence-quality printer

Manufacturer
Integral Data Systems
Milford NH 03055

Dimensions
31 by 40 by 32 cm (12½ by 15¾ by 12½ inches)

Price
$1295

Hardware
Any computer capable of sending ASCII characters via parallel or serial interface: requires standard RS-232 cable (not supplied)

Software
None, apart from the standard printer driver for a particular operating system

Hardware Options
Dot Plot graphics, paper-roll holder, paper-catch basket, letter carrier, various interfacing cables and connectors

Features
Printer speed, 150 cps; paper slew rate, 5½ inches per second; built-in self test and diagnostics; printing pitch sizes of 5, 10, 12, 16.8 characters per inch; fixed/proportional spacing; software-controlled text justification; line buffering (extended buffering with graphics); bidirectional printing; selectable line spacing; selectable page format; variable line length; programmable functions; impression control

Power Requirements
115 VAC at 60 Hz or 230 VAC at 50 Hz (for European operation); user selectable

Documentation
Comprehensive 65-page illustrated owner's manual

Audience
Anyone desiring both letter-quality and high-speed printout

basket and a letter carrier that allows printing of letters on single sheets.

The ribbon comes in a sealed cartridge, which "facilitates fast, easy replacements" according to the manufacturer. The ribbon must still be handled manually, however, and I did not find the cartridge any easier to install than an ordinary—and far less expensive—spool.

Although this ribbon is said to have a longer life than an ordinary ribbon, it is easily tangled when the enclosure is removed and replaced; then the cartridge must be discarded. A new one costs $12. The user is warned to use only cartridges supplied or approved by Integral Data Systems, although the item appears to be standard.

The IDS 460 can be connected immediately to almost any computer. Other printers require that the buyer specify the interfacing standard when placing an order. This printer has built-in circuitry for almost any interfacing standard. A jumper selects either parallel (Centronics-compatible) or RS-232 serial interfacing. The XON/XOFF handshaking protocol used by many of the daisy-wheel printers is also recognized. The user can select any one of five serial baud rates up to 9600 baud by using the DIP switches on the top of the printer. The DIP switches also allow the user to easily define the parity-checking functions for received data.

I had a little difficulty getting the printer to operate properly when connected to my LSI-11/2-based system. The individual I spoke to at IDS was knowledgeable and helpful. He suspected that the problem might be traced to the printer's firmware and offered to send me a set of revised PROMs. I discovered that the problem was not in the printer at all; nevertheless, the new PROMs arrived promptly, and at no cost.

The IDS 460 shines particularly well in the area of print quality: it is superb and well complemented by a powerful array of character and forms-control options. The characters are clear, crisp, and well formed. The letters are not the mere outlines produced by most dot-matrix printers, but are shapely and filled in, almost like letters off a printing press. Distinct dots are not visible because the print head produces the dots in an overlapping pattern.

Four different print densities are software or DIP switch selectable—5, 10, 12, or 16.8 characters per inch. The following are also hardware or software selectable: proportional spacing (you can even control the amount of space between characters), text justification (!), line spacing at either 6 or 8 lines per inch, and one of eight form lengths, from 3 to 14 inches. And despite the excellent print quality, the speed of the printer compares favorably with the faster dot-matrix printers. The IDS 460 uses bidirectional printing and logic that minimizes motion of the print head over white space on the page.

The IDS 460 firmware performs many of the functions normally handled by text editors; it should be relatively easy to program a text editor to take advantage of the

```
The IDS 460 -- A Demonstration

10 PRINT "For program listings, a 'no frills' format is preferred."
20 PRINT "In that case, one would use the standard 80 column listing"
30 PRINT "with no proportional spacing or text justification "
40 END
```

For word processing, however most writers will opt to use proportional spacing This means that individuals letters will be of different widths, giving the document a more professional appearance The ability to do this is characteristic of better letter quality printers.

Notice that more characters can be fit on a line that is proportionally spaced, giving the text a "smaller" look When one uses the smallest type size in conjunction with the proportional spacing feature the result is text that is quite small -- suitable for footnotes, perhaps.

This size is the one that I generally use, 12 characters per inch. The IDS 460 is a versatile printer The manufacturer promises to make it even more versatile by making available PROM chips to enable switching between two typefaces With this feature it would be possible to switch back and forth from a language to another. However, if you do not want to wait for the PROM chips to become available, you can accomplish the same thing by using the graphics function of this printer

"I hear you have a new printer, Eli, מזל טוב!"

Figure 1: *Sample printout of the Integral Data Systems' Model 460. Although the Hebrew characters in the last line were printed using graphics features, IDS is planning to introduce PROMs that will permit switching from one language to another.*

many features. Examples of some of these features include the following: the DIP switches may be used to enable or disable an automatic one-inch skip at form boundaries; horizontal tab positions can be set by using software escape sequences; on receiving a horizontal tab character, the print head tabs to the next specified column in the line. You can also set vertical tab positions—in fact, you can program three separate vertical tab schedules since there are three separate vertical tab characters. Print-head motion and paper motion are extremely precise. Horizontal tabbing may be specified in 1/120 inch increments; vertical tabbing in 1/12 inch increments.

One other minor inconvenience is that no default tab setting takes effect when the printer is powered up. This means that unless the user remembers to explicitly program tab positions, the printer ignores the tab character. In text, the tab character is frequently used, instead of blanks, to conserve storage space. If you send such text to the printer before setting tabs, the text will look as if all the blanks mysteriously disappeared. The solution is simply to set the tabs, but there really should be a default setting.

In addition to its text-processing prowess, the IDS 460, when equipped with the Dot Plot option, is an excellent graphics printer. Sending a control-C to the printer puts it into graphics mode, and every following character is interpreted as a graphics pattern until graphics mode is switched off with another control-C.

Each character controls seven dots in the vertical plane. Each bit in the 7-bit ASCII (American Standard Code for Information Interchange) code of the character activates a different dot, with the leftmost bit corresponding to the lowest of the seven dots. If the ASCII code sent is 1000011, for example, the IDS 460 prints the bottom dot and the two top dots. A graphics carriage control advances the paper a distance of seven dots.

Conclusions

- The IDS 460 has excellent print quality—probably the best of all dot-matrix printers in its price range. The nine-wire head uses both vertical and horizontal overlapping of dots to make fully formed characters and give lowercase letters full descenders.
- The bidirectional, logic-seeking printing minimizes print-head motion and assures high-speed operation.
- Interfacing the IDS 460 to a variety of printers is remarkably simple because the printer contains *both* RS232 and parallel interfaces.
- The only real drawbacks result from the difficulty of removing the cover and the placement of the print-intensity switch inside. Before changing from paper of one thickness to paper of another thickness, the user must remove the cover and adjust the print-intensity switch.
- Although the printer lacks a friction-feed feature and can't handle single sheets of paper, it does offer extremely precise paper handling.
- The IDS 460 has a convenient self-test feature and an indicator that lights or flashes when paper runs out or hardware problems occur.
- When equipped with the Dot Plot option, the IDS 460 offers outstanding graphics features.
- Judging by its willingness to help when I encountered a problem, Integral Data Systems can be relied on for product support.
- I recommend the IDS 460 to anyone who can't spend several thousand dollars and yet needs a printer that has both excellent print quality and the speed of dot-matrix technology. ■

The Mauro Proac Plotter

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The Mauro Proac plotter provides the small-computer user with an inexpensive way of obtaining high-quality graphics. The plotter uses a novel method of controlling the paper—it embosses a pattern on the edge of the paper that is used to guide the paper across the drive roller. A centrifugal blower creates a pressure drop across the paper writing surface, assuring that the paper is held in place. Both X and Y axes are driven by stepper motors, and the pen is moved up and down by a solenoid.

The plotter will accept single 21.5- by 28-cm (8½- by 11-inch) sheets, 28- by 43-cm (11- by 17-inch) sheets, or a 28-cm (11-inch) continuous roll (if equipped with the roll-paper option).

At a Glance

Hardware
Mauro MP-250
Proac plotter

Use
general-purpose plotter

Manufacturer
Mauro Engineering
Rt 1 Box 133
Mount Shasta CA 96067
(916) 926-4406

Price
plotter, $695
RS-232C serial interface, $195
TRS-80 or Apple interface, $85

Features
plots on ordinary 8½ by 11 paper
choice of pen colors and line widths
0.005 inch/step resolution
2.5 inch/second plotting speed

Software
full vector driver software available for 8080/Z80, 6502, and 6800 microprocessors; two-dimensional and perspective plotting packages available; may be driven from FORTRAN, BASIC, etc.

Hardware required
any 8080/Z80, 6502, or 6800 microprocessor; requires either a 6-bit parallel output port or the RS-232C interface option.

Hardware options
roll paper adapter
RS-232C serial data interface
TRS-80 or Apple II interface cards

Documentation
26-page manual including interfacing requirements, sample software drivers, and a listing of the 8080 assembler interface program.

Audience
anyone requiring quality pen-plotter graphics at low cost.

Control Circuit

The electronics package will accept control signals from the host computer via six data lines: −Y, +Y, −X, +X, pen-control (up/down), and home. Limit switches are provided on all axes to prevent overrun of the pen. The electrical interface consists of TTL (transistor-transistor logic) signals. All lines come out to a 10-pin Molex connector on the back of the plotter.

Sending commands to the plotter is somewhat more complicated. For example, if you want to step in the +X direction, you have to hold the −X line high (logic 1) and send four positive-going pulses to the +X input. This causes the motor to advance one 0.005-inch step in the +X direction. The same procedure is required for the other three controls (−X, +Y, and −Y). The pen may be lowered by pulling the pen-control line low (logic 0) after it has been placed in the high (logic 1) state. Raising or lowering the pen takes approximately 100 ms.

Serial Interface

The serial interface allows users with an RS-232C serial data port to communicate with the plotter without having to wire up a special cable for the parallel interface. It normally runs at 1200 bps (bits per second), but may be switched to 110, 300, or 2400 bps. The interface expects to see 7 data bits and 1 or 2 stop bits. The eighth, or parity, bit is ignored. To communicate with the serial interface, several bytes are sent in the following sequence:

Byte 0: Control word
Byte 1: Y LOB, (low-order bits) bits 0 to 6 (bit 7 ignored)
Byte 2: Y HOB, (high-order bits) bits 0 to 4 (bit 5 is the sign bit, and bit 6 is the pen-control bit)
Byte 3: X LOB, bits 0 to 6 (bit 7 ignored)



Photo 1: *The Mauro plotter is a low-cost, well-engineered unit designed with the small-system user in mind.*

Byte 4: X HOB, bits 0 to 4 (bit 5 is sign bit, bits 6 and 7 are ignored)

The control word tells the interface how it should interpret the succeeding bytes. Bits 0, 1, and 2 define how many vectors (4-byte groups of bytes 1 through 4) will be sent. Bit 4 indicates whether the buffer-full response of the interface is a pulse on the RS-232C CTS (Clear to Send) line or a specific character. Bits 3, 5, and 6 are reserved, and bit 8 is ignored.

Software

Several device drivers for the 8080/Z80, 6800, and 6502 microprocessors (in both BASIC and assembly language) are provided with the plotter and the interface. The program driving the plotter (without the serial interface) uses the same byte order and format as the above protocol for the serial interface. This greatly simplifies conversion (not to mention program compatibility) from one to the other.

Another vendor—Leapac Services (8245 Mediterranean Way, Sacramento CA 95806)—supplies several two- and three-dimensional plotting packages at reasonable prices. The L2D package is a simple two-dimensional package with Calcomp-compatible routines. The L3P is a three-dimensional perspective-plot package containing over seventy subroutines, including zoom, fly-by, and animation functions.

Both packages are available from Leapac on either CP/M-format 8-inch floppy disks or North-Star-format 5-inch disks. Each package is provided as a linkable library for Microsoft-compatible compilers such as FORTRAN-80, COBOL-80, MACRO-80, and the BASIC compiler.

Conclusions

In general, I found the documentation of the Mauro plotter to be adequate but not exceptional. The plotter itself is well engineered and constructed. I had few problems with the unit, except for a troublesome serial interface. However, this was quickly replaced after a call to Mauro Engineering. Of the many plotters I have looked at over the past three years (with hopes of finding one I could afford), the Mauro Proac plotter comes closest to being the ideal small plotter. ■

The Radio Shack FORTRAN Package

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FORTRAN, a high-level programming language geared to scientific and mathematical programming, is probably one of the few languages to have found "universal" acceptance. Until recently, however, FORTRAN (FORmula TRANslator) has been unavailable to the personal computer user.

For those who are familiar only with BASIC (Beginner's All-Purpose Symbolic Instruction Code), a few words concerning "compiled" and "interpreted" languages are in order. BASIC as implemented on the TRS-80 is an *interpreted* language. As a program runs, it is translated, line by line, from English (which the computer can't understand) to the computer's own "machine language." Each line of the program is executed as it is interpreted. Note that the program (called *source code*) never changes: it is simply interpreted each time you type the RUN command.

FORTRAN, on the other hand, is a *compiled* language. As in BASIC, the source code is written in English-like statements which, though not identical to those in BASIC, are similar in principle (ie: there are such elements as input/output statements, arithmetic expressions, and logical expressions). To run the FORTRAN program, however, you must use a special machine-language routine called a *compiler*. The compiler goes through source code and creates a second machine-language program, called *object code*. This transformation from source to object code is performed once—thereafter, when you want to run your program, you actually execute the machine-language object code produced by the compiler.

For this reason, programs written in compiled languages such as FORTRAN are very fast: typically twenty to thirty times faster than the equivalent algorithm written in an interpreted language. The price for this efficiency is increased difficulty in editing and debugging because a program must always be compiled before it can be run.

The Package

With the exception of a few extensions and restrictions, the FORTRAN package described here conforms to the 1966 ANSI (American National Standards Institute) FORTRAN. Radio Shack's FORTRAN (actually written by Microsoft and licensed to Radio Shack) comes in a three-ring binder that includes two 5-inch floppy disks and about 200 pages of documentation. The documentation is not a tutorial in FORTRAN, however, and if you don't know FORTRAN, it is probably insufficient. Radio Shack recommends several textbooks to augment the information supplied.

The FORTRAN package comprises four files. Disk 1 contains the FORTRAN compiler and the editor; Disk 2 contains the linking loader and the FORTRAN library. Each file has an associated section of documentation, and there is a sample FORTRAN program, along with instructions for entering, compiling, linking, and running it. Each disk has the TRSDOS 2.3 operating system on it.

At a Glance

Name
Radio Shack FORTRAN

Type
High-level language compiler

Manufacturer
Licensed by Microsoft to Radio Shack
One Tandy Ctr
Forth Worth TX 76102
(817) 390-3011

Price
$99.95

Format
Two 5-inch floppy disks

Language
Z80 machine language

Computer
Radio Shack Model I Level II with expansion interface, minimum 32 K bytes of memory, and at least one disk drive (two recommended)

Documentation
Approximately 200 pages in a loose-leaf binder

Audience
Language enthusiasts, FORTRAN users, and users with scientific and mathematical applications

The documentation claims that the Disk BASIC files are included, but they were nowhere to be found on my copies.

Although this FORTRAN package is best suited for systems with dual disk drives, I was able to use it successfully on a single drive system. The only real disadvantages were that I had to exchange the disks constantly (a problem familiar to anyone who has tried to make a copy of a disk using a single drive system), and the amount of free disk space was limited. The reason for this is that the disk containing the final executable command files—created from your source code—will always contain part of the FORTRAN software. This will be discussed later in the article.

The Editor

The Microsoft heritage is most apparent in the editor. Anyone familiar with the Level II BASIC or Microsoft EDTASM (Editor-Assembler) editing commands will feel right at home with this editor. It is also the best-documented portion of the package, although in my

Extensions to ANSI-66 FORTRAN

- *If c is used in a 'STOP c' or 'PAUSE c' statement, c may be any six ASCII characters.*
- *Error and end-of-file branches may be specified in READ and WRITE statements using the ERR= and END= options.*
- *The standard subprograms PEEK, POKE, INP, and OUT have been added to the FORTRAN library.*
- *Statement functions may use subscripted variables.*
- *Hexadecimal constants may be used wherever Integer constants are normally allowed.*
- *The literal form of Hollerith data (character string between apostrophe characters) is permitted in place of the standard nH form.*
- *Holleriths and Literals are allowed in expressions in place of Integer constants.*
- *There is no restriction to the number of continuation lines.*
- *Mixed-mode expressions and assignments are allowed, and conversions are performed automatically.*

Restrictions on ANSI-66 FORTRAN

- *The COMPLEX data type is not implemented. It may be included in a future release.*
- *The specification statements must appear in the following order:*
  - *a) PROGRAM, SUBROUTINE, FUNCTION, BLOCK DATA*
  - *b) Type, EXTERNAL, DIMENSION*
  - *c) COMMON*
  - *d) DATA*
  - *e) Statement functions*
- *A different amount of computer memory is allocated for each of the data types: Integer, Real, Double Precision, and Logical.*
- *The equal sign of a replacement statement and the first comma of a DO statement must appear on the initial statement line.*

judgment it presents the least difficulty.

The purpose of the editor is to create, edit, and store FORTRAN source code. It assigns line numbers and increments to the program statements. The line numbers are not actually part of the FORTRAN program, but they exist so that specific lines can be called for editing. Only certain FORTRAN statements such as DO loops and WRITE operations require line numbers, and these are included in the FORTRAN statement-field.

The usual interline and intraline editing commands are provided. The interline commands can insert, delete, replace, and print lines, or groups of lines, in the program. The intraline commands edit characters or groups of characters within a given program line (eg: a character can be deleted within a line of the program and then replaced with three other characters).

The line editing commands are simply extensions of the editing facilities provided with Radio Shack's Level II and Disk BASIC software. However, the elegance of this editor is substantiated by the presence of two other commands: Find and Substitute. The Find command finds a given string of text within a source file and prints out the corresponding line numbers. The Substitute command is similar to the Find command, except that a given character string can be replaced with another character string in a selected group of lines. It would, for example, be possible to substitute FORMAT(2 for FORMAT(5 wherever it appears in lines 100 to 500. These two commands are tremendous time-savers, particularly if you are editing long files in which the same change must be made many times.

There are two final features of interest. First, as is common to most FORTRAN source listings, the editor appends page numbers to the listing, as necessary, which facilitates the organization of long files. Second, the editor can be used to edit certain BASIC and other non-FORTRAN files. (The BASIC file must be stored as a text file.) This allows you to use the find/substitute commands when editing BASIC files.

The Compiler

The FORTRAN user never comes into direct contact with the compiler. Rather, he writes source code according to the strict grammatical rules of the language. The compiler in turn is able to recognize and process the source code. As mentioned previously, this FORTRAN fundamentally conforms to the ANSI-66 standard. The text box on the left, excerpted from the reference manual, shows the departures from the standard.

FORTRAN is recognized as a language that is well-suited to the scientific and mathematical user. This bias is reflected in the data types that are available:

Integer: from −32768 to 32767
Real: seven-digit precision from $\pm 10^{-38}$ to $\pm 10^{+38}$
Double precision: same as real except with 16-digit precision
Logical: used in logical operations such as AND, OR
Literal: alphanumeric strings
Hexadecimal: numbers in base 16

One glaring omission is the complex data type. Standard ANSI FORTRAN allows direct manipulation of complex variables—a real time-saver when solving problems in physics, electronics and related fields. I suspect that this data type was omitted because of the memory it would require to handle complex variables. Nevertheless, it should have been offered as an option (ie: two versions of the compiler, one with and one without the complex variable type).

This version of FORTRAN is characterized by extensive formatting statements that give the programmer great control over how data is input, output, and stored. These statements include numeric, logical, Hollerith (or string), and scaling-type format commands. User-defined functions are also allowed through the construction of function subprograms. The usual transcendental functions, such as sine, cosine, and arctangent, are included, as well as the hyperbolic tangent. And, of course, the package includes all standard FORTRAN arithmetic and control statements such as GOTO (three kinds), IF, and PAUSE.

The Linker and FORTRAN Library

The linker relocates in memory the object code that was created by the compiler, and it must do so in a manner that will allow the object code to be directly executed. In other words, the linker goes through the relocatable object file that the compiler has created, and from this, creates a command file that can be directly executed under TRSDOS 2.3. During this process, the linker references another file called FORLIB. FORLIB contains all the standard routines for addition, subtraction, transcendental functions, etc, so the compiler does not have to recreate the same machine-language routines that appear commonly. Rather, it references the FORTRAN subroutine library as necessary.

FORTRAN Patchwork

I found a few bugs in Radio Shack's FORTRAN editor that were not apparent at first. On the whole, they are minor, such as the inability to stop screen scrolling with "<SHIFT> @". But a rather severe bug exists when index files are created. The editor creates an index file when extremely long source files are written. This helps in loading large source files during subsequent editing sessions. Unfortunately, I got "garbage" in my program source listings when files were augmented by Edit-80-created index files. Killing the index file and loading the source file without it fixed the problem. Your local Radio Shack dealer has two patches to rectify these problems: one for Disk EDTASM (catalog number 700-2210) and one for FORTRAN (catalog number 700-5210). . . . TD

Running the System

Four steps are required in order to use the system:

1. Writing and editing the FORTRAN program
2. Compiling the source code to relocatable object code
3. Linking the object code to memory and creating a command file
4. Executing the program

One particularly nice feature of the compiling process is that it will, at your request, not only create an object file, but also an assembly-language listing of your program. It's a great way to learn how your computer "thinks" FORTRAN. One other advantage of the package also appears at the time of compilation. If you wish, you can compile the source code down to machine code that is suitable for loading into ROM (read-only memory).

To check for syntax and other errors in your FORTRAN program, you can compile the code without creating the object file on disk. The compiler runs through the program and then displays error and warning messages. Once an error-free object file is created, it is linked. It can then be run immediately or stored as a command file to run under TRSDOS 2.3. In single drive systems, the relocatable object file must always be on the disk containing the linker and FORTRAN library. Consequently, free disk space is limited since these two files occupy 25 grans of space.

Benchmarks

If you've never used FORTRAN, you're probably asking, "Why go through all this effort to write and execute a program?" The answer is threefold: speed, speed, and speed! There is no doubt that virtually any problem solved in FORTRAN could be solved, say, in BASIC. But unless you enjoy waiting, you should consider FOR-

Listing 1: *Benchmark programs that compare Radio Shack BASIC, an interpreted language, with Radio Shack FORTRAN, a compiled language. The BASIC program (1a) took almost twenty times as long as the FORTRAN program (1b) to calculate the answer.*

(1a)

```
100  DEFDBL C,D:DEFINT A,B
105  FOR A=0 TO 100
110  FOR B=0 TO 100
115  C=(A↑2)+(B↑2)
120  D=D+C
125  NEXT B,A
130  PRINT TAB(20)D
135  END
```

(1b)

```
00100          DOUBLE PRECISION C,D
00105          INTEGER A,B
00110          DO 10 A=0, 100
00115          DO 20 B=0, 100
00120          C=(A**2)+(B**2)
00125          D=D+C
00130    20    CONTINUE
00135    10    CONTINUE
00140          WRITE(5,30)D
00145    30    FORMAT (20X,D15.9)
00150          END
```

TRAN for "number crunching" applications.

The benchmark that is described here demonstrates this difference vividly. It consists of nested loops in which two numbers are squared, added together, and then added to the previous total. Listings 1a and 1b show the program listings. Note that the eight-line BASIC program looks fairly innocuous; it took 20 minutes, 44 seconds, to run. Once the FORTRAN program was compiled and linked, the command file required only 1 minute, 4 seconds, to run. (I also had a chance to run a similar program using CBASIC 2 running under CP/M. Even this compiled BASIC ran about 4 minutes—over three times as long as FORTRAN.)

However, in terms of total time required, the languages are fairly comparable. It took me almost 20 minutes to write, edit, compile, and link the FORTRAN program, whereas the BASIC program occupied about 4 minutes to write and edit. This won't always be true, for in longer, less trivial programs, FORTRAN will come out ahead every time. This is particularly true for programs that are reused, since linking and compiling are one-time operations. In such instances the command file will run in just over a minute, whereas the BASIC program will always leave you time to watch the evening news.

Conclusions

- The FORTRAN package is powerful and elegant.
- The price is right. At a little less than $100, this package compares favorably to software at three times the cost.
- My biggest complaint is the absence of the complex data type. No FORTRAN system should be without it.
- If you're tired of long run times and you aren't challenged by BASIC anymore (or you just want to expand your programming horizons) this is the package for you. ■

The Variable-Duty-Cycle Algorithm

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Every now and then a novel technique for handling data comes to light which, while not immediately obvious, is actually very simple and can be used in a wide variety of applications.

One example of such a technique is the use of the *linked-list* data structure, which allows the programmer to create ordered sets of entries into which new entries can be inserted and from which existing entries can be easily deleted. Another example is the use of *semaphores*, which have many applications that center around the allocation of resources to sets of processes.

A new technique in this category has recently been added to the list. Pioneered by Albert G Love of General DataComm Industries, the technique initiates an event so that it occurs a specified proportion of the times that another event occurs.

Let us call the event that is conditionally initiated the "kickee," and the other event, typically something that occurs at even intervals in time or space, the "kickor." Now define three quantities, called the *duty-master*, the *duty-cycle*, and the *duty-counter*. The ratio of the duty-cycle to the duty-master will determine the proportion of kickee to kickor events. (The duty-counter is a scratch quantity that will ordinarily be initialized, say at power-up, to zero.) Each time the kickor event occurs, we do the following:

```
duty-counter := duty-counter minus duty-cycle
if duty-counter is now negative
then do
   <initiate kickee>
   duty-counter := duty-counter plus duty-master
end
```

This procedure may seem sufficiently abstract as to be totally useless, so let's consider a concrete example: a D/A (digital-to-analog) converter constructed of one bit from a computer parallel output port, one resistor, and one capacitor. The resistor and capacitor are connected so as to form a simple low-pass filter, as shown in figure 1. Now you can run the BASIC program shown in listing 1 on the computer.

Depending on the values of resistance and capacitance, and the speed at which the program executes, the voltage at the analog output point will be a more or less steady 3.75 V. By changing the constant in the DATA statement in line 100, any arbitrary voltage between 0 and 5 V can be obtained.

In this example, the duty-master is the constant 5 appearing in line 70, the duty-cycle is the variable V, and the duty-counter is the variable C. The kickor is the occurrence of a pass through the loop extending from line 30 to line 90, and the kickee is the decision to output a 1,

Listing 1: *This BASIC program uses the VDC algorithm to provide a steady output voltage when combined with the simple circuit in figure 1. A change in the value of the DATA statement will alter this voltage. Program line 80 must output the contents of B to the appropriate output port.*

```
10 C=0
20 READ V
30 B=0
40 C=C-V
50 IF C>=0 THEN 80
60 B=1
70 C=C+5
80 <output B to port>
90 GOTO 30
100 DATA 3.75
```

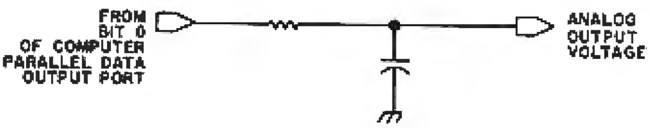


Figure 1: *Low-pass filter that converts the digital output of the single-bit data port to an analog signal.*

instead of a 0, to the port. The utility of this example could be considerably enhanced through the use of assembly language and real-time interrupts, but the utility of the basic scheme should be clear: assuming that each pass through the loop requires the same amount of time, the waveform output to the port will have an average duty-cycle precisely equal to the ratio between the duty-cycle, V, and the duty-master, 5. In addition, the waveform will bounce back and forth between 0 and 5 V at the maximum possible rate given the desired duty cycle and the available processing time, which will make the low-pass filter's job as easy as possible in reducing ripple at the analog output.

The variety of ways in which this same basic technique can be applied is extraordinary. Consider the case in which two integer quantities need to be kept as close to a given ratio as possible while both are gradually increased from zero to some higher number. Normally this would involve substantial amounts of multiplication and/or division, or have drawbacks in terms of either minimum increment size or worst-case error. However, use of the VDC (Variable-Duty-Cycle) algorithm makes the task straightforward: simply call the two integers I and J, and let the desired ratio between them be K:L. Pick a number, M, which is greater than or equal to both K and L, and, each time you wish to increase I and/or J by a small amount, do the following:

```
C := C-K
if C<0
then do
   <increment I>
   C := C+M
end
D := D-L
if D<0
then do
   <increment J>
   D := D+M
end
```

This process, of course, merely combines two instances of the VDC algorithm, using a common duty-master, M. The duty-cycle quantities are K and L, the duty-counters are C and D. The method requires virtually no processing time or memory space, is completely processor- and language-independent, and presents no theoretical limitation on the degree of precision with which the desired ratio may be maintained.

Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

Nothing that we have seen so far suggests that the duty-cycle quantity could not vary from one occurrence of the kickor to the next. This is very handy for, among other things, modeling the effects of acceleration and velocity upon the position of an object. Suppose we are designing a real-time graphics game in which there will be a cannon capable of launching a projectile on a parabolic path toward a target. Is it possible to generate a parabolic path without resorting to a multiplication routine? Indeed it is!

We accomplish this by treating the projectile's horizontal and vertical velocity components as duty cycles, where the common kickor is a routine that runs at evenly spaced intervals in time, and the kickees are routines that move the projectile one cell horizontally and one cell vertically. Typically, the projectile's horizontal velocity component is a constant in the forward direction, and is easy to handle using the formula we have seen here. To deal with the possibility that the projectile could, vertically, be moving either up or down, we will have to introduce the concept of a negative duty-cycle. If M is the duty-master, H and V the horizontal and vertical duty-cycle/velocities, and C and D the duty-counters, the kickor routine looks like this:

```
    C := C-H
    if C<0
    then do
       <move projectile one cell to the right>
       C := C+M
    end
    D := D-V
    if D<0
    then do
       <move projectile one cell up>
       D := C+M
    end
  else if D> =M
  then do
    <move projectile one cell down>
    D := D-M
  end
<decrease V by a fixed amount>
```

Photo 1 shows the set of projectile positions that are obtained when M is 125, H is 25, and V starts off at 75 and is decremented each kickor pass by 1 until it reaches −75.

More complex (but perhaps less useful) patterns can be generated if the kickee is permitted to change the value of the duty-cycle or duty-master, if the kickee of one VDC is made the kickor of another, and so on. But even in the simple forms given here, the applications of this algorithm range from data-communications multiplexing to printer/plotter control to industrial process simulation to—who knows what? Perhaps you will be the next to add to the list. ■

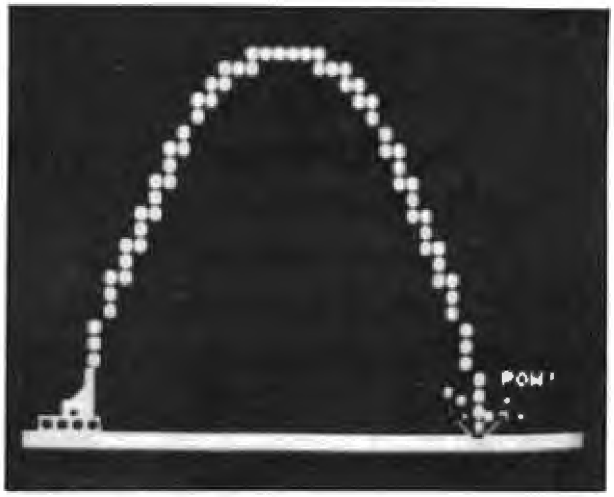


Photo 1: *The VDC algorithm can be used to predict the parabolic path of a projectile without the use of multiplication or division.*

Dynamic Simulation in BASIC

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If you plan to parachute out of an airplane, you may want to know the terminal velocity of the open chute. If you are an amateur rocket launcher, you may want to know what orbits can be obtained from a preprogrammed multistage rocket. Answers to these questions can be quickly obtained from a personal computer programmed in BASIC.

In general, dynamic systems can be represented by a set of ordinary differential equations, such as those shown in the figures. The solution can be found by computer simulation using numerical analysis. We will use Euler's method to solve a set of differential equations.

Euler's method states that for a given first-order equation

$$\frac{dx}{dt} = f(t,x)$$

the solution can be obtained by the following routine:

$$x_{n+1} = x_n + hf(t_n, x_n)$$
$$t_{n+1} = t_n + h$$

where:

$$n = 0, 1, 2, \cdots$$

The solution x_{n+1} at the time t_{n+1} can be calculated from the previous solution x_n at t_n. Therefore, the complete solution can be found, step by step, from the given initial condition x_0 at t_0. The parachuting problem in figure 1 can be solved, in BASIC, by repeatedly using the following statements in a BASIC program:

```
V=V+H*(G-D*V*V/M)
T=T+H
```

Begin with the initial velocity V and time T.

Euler's method definitely solves first-order equations. But how about the second-order equations in figures 2 through 4? We need a magic (mathematical) transformation here. For a given second-order equation:

$$\frac{d^2x}{dt^2} + A\frac{dx}{dt} + Bx = F$$

if $x_1 = x$ and $x_2 = dx/dt$, we obtain the following simultaneous first-order equations:

$$\frac{dx_1}{dt} = x_2$$

$$\frac{dx_2}{dt} = F - Ax_2 - Bx_1$$

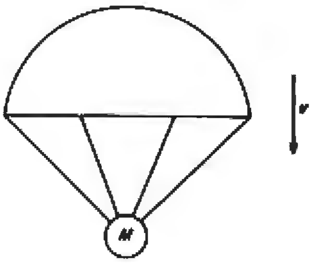
The above equations are mathematically equivalent to the original second-order equation. Euler's method can be applied to solve them in BASIC as follows:


```
F1=H*X2
F2=H*(F-A*X2-B*X1)
X1=X1+F1
X2=X2+F2
T=T+H
```

Start with the initial conditions X1 and X2 at T.

This magic transformation can be easily extended to the *n*th-order equation. The result is a set of *n* simultaneous first-order equations that can be solved by Euler's method.

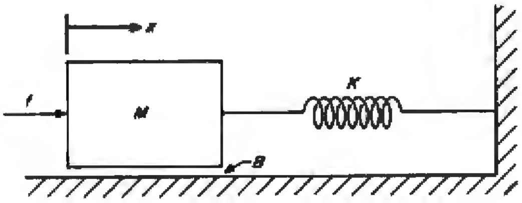
This same transformation can also be applied to the moon-landing and rocket-launching problems in figures 5 and 6. Each second-order equation produces two first-order equations. The result is a set of four simultaneous



v = velocity
M = mass
D = drag
g = gravity.

$$\frac{dv}{dt} = g - \frac{D}{M}v^2$$

Figure 1: *Determining the terminal velocity of a mass descending by a parachute requires solving a first-order differential equation. Computers can solve this equation using Euler's method.*



x = displacement
M = mass
K = spring
B = friction
f = force

$$\frac{d^2x}{dt^2} + \frac{B}{M}\frac{dx}{dt} + \frac{K}{M}x = \frac{f}{M}$$

Figure 2: *Solving the second-order differential that describes a dynamic mass-spring-friction system requires transforming the second-order equation into two simultaneous first-order equations and applying Euler's method.*

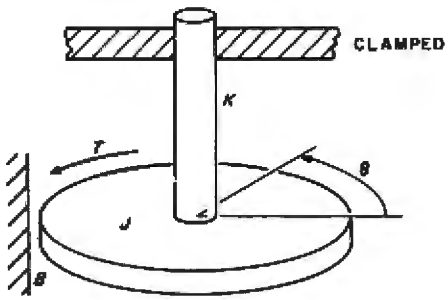
first-order equations for each problem. For example, in the rocket-launching problem, if $x_1 = R$, $x_2 = dR/dt$, $x_3 = \theta$, and $x_4 = d\theta/dt$, we obtain:

$$\frac{dx_1}{dt} = x_2$$

$$\frac{dx_2}{dt} = \frac{T}{M}\sin\phi - g + x_1(x_4)^2$$

$$\frac{dx_3}{dt} = x_4$$

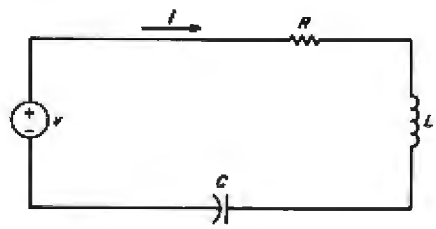
$$\frac{dx_4}{dt} = \frac{T}{M}\cos\phi - \frac{2}{x_1}(x_2)(x_4)$$



θ = angular displacement
J = moment of inertia
K = spring
B = friction
T = torque

$$\frac{d^2\theta}{dt^2} + \frac{B}{J}\frac{d\theta}{dt} + \frac{K}{J}\theta = \frac{T}{J}$$

Figure 3: *Euler's method can also be applied to the second-order differential equation of a rotational system.*



q = charge
i = current
v = voltage
R = resistance
L = inductance
C = capacitance

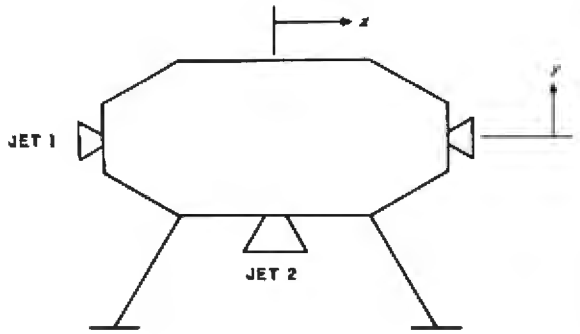
$$i = \frac{dq}{dt}$$

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{LC} = \frac{v}{L}$$

Figure 4: *This RLC (resistive-inductive-capacitive) circuit is described by both first-order and second-order differential equations.*

The corresponding BASIC programming is:

```
F1=H*X2
F2=H*(T1*SIN(P1)/M-G+X1*X4*X4)
F3=H*X4
F4=H*(T1*COS(P1)/M-2*X2*X4/X1)
X1=X1+F1
X2=X2+F2
X3=X3+F3
X4=X4+F4
T=T+H
```

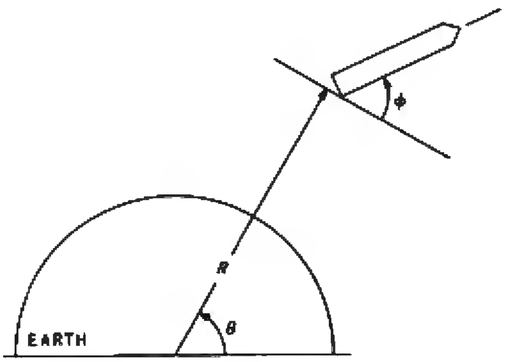


x,y = displacement
Jet1,Jet2 = thrust
g = gravity

$$\frac{d^2x}{dt^2} = \pm \frac{Jet1}{M}$$

$$\frac{d^2y}{dt^2} = g - \frac{Jet2}{M}$$

Figure 5: *Euler's method can be applied to a moon-landing simulation, solving the four simultaneous first-order equations derived from two second-order differential equations.*



R = radial displacement
θ = angular displacement
M = mass
g = gravity
T = thrust
ϕ = turnover angle

$$\frac{d^2R}{dt^2} - R\left(\frac{d\theta}{dt}\right)^2 = \frac{T}{M}\sin\phi - g$$

$$\frac{d^2\theta}{dt^2} + \frac{2}{R}\left(\frac{dR}{dt}\right)\left(\frac{d\theta}{dt}\right) = \frac{T}{M}\cos\phi$$

Figure 6: *Solving this rocket-launch simulation involves applying Euler's method to four simultaneous first-order differential equations.*

Listing 1: *A BASIC program that uses Euler's method for solving differential equations. The example is used to solve the two first-order differential equations derived from the mass-spring-friction system in figure 2.*

```
1 REM MASS-SPRING-FRICTION SYSTEM
5 H=0.1
10 PRINT"FRICTION B/M=",
20 INPUT B
22 IF B<0 THEN END
24 PRINT"NO. OF DATA=",
26 INPUT N
30 X1=0
40 X2=0
50 T=0
60 FOR I=1 TO N
70 FOR J=1 TO 2
80 F1=X2
90 F2=1-B*X2-X1
100 X1=X1+H*F1
110 X2=X2+H*F2
120 T=T+H
130 NEXT J
140 PRINT"T=";T,"X1=";X1,"X2=";X2
150 NEXT I
160 GOTO 10
```

```
FRICTION B/M= ? 0.4
NO. OF DATA= ? 10
T= .2       X1= .01          X2= .196
T= .4       X1= .058316      X2= .372714
T= .6       X1= .140785      X2= .524336
T= .8       X1= .252147      X2= .646391
T= 1        X1= .386318      X2= .735829
T= 1.2      X1= .536677      X2= .791063
T= 1.4      X1= .696359      X2= .811945
T= 1.6      X1= .858536      X2= .799682
T= 1.8      X1= 1.01669      X2= .756717
T= 2        X1= 1.16484      X2= .686553
FRICTION B/M= ? -9
```

Starting with the initial location (R,θ) and velocity $(dR/dt, d\theta/dt)$, the launching orbit can be calculated with the turnover function $\phi(t)$ and the multistage rocket-thrust function $T(t)$.

One question remains. What value of h should be used in Euler's method? The h is the time increment (or step size) of the computation. Based on the numerical analysis, h must satisfy the following stability condition:

$$h < \frac{2}{\left| \frac{\partial f(t,x)}{\partial x} \right|}$$

to have a stable numerical computation. The computed solution approximates the exact solution if the value of h is chosen according to the stability condition; otherwise the computed solution may not be a solution at all. In practice, we have to use the maximum estimated value of the partial differentiation $|\partial f/\partial x|$ in the stability condition. This guarantees a stable computed solution for all cases.

Let's try Euler's method on the mass-spring-friction system shown in figure 2. The analytic solution of the system is well known. Thus, we can use this computer example as a test for the accuracy of Euler's method. Assume the following data:

forcing function $\left.\frac{f}{M}\right| \begin{array}{l} = 1, \text{ for } t \geq 0 \\ = 0, \text{ for } t < 0 \end{array}$

spring/mass ratio $\frac{k}{M} = 1$

friction/mass ratio $0 \leq \frac{B}{M} \leq 10$

and the initial conditions, $x(0)=0$ and $dx(0)/dt=0$ at $t=0$. The equivalent simultaneous first-order equations are:

$$\frac{dx_1}{dt} = x_2 = f_1$$

$$\frac{dx_2}{dt} = 1 - \frac{B}{M}x_2 - x_1 = f_2$$

The partial differentiations are:

$$\frac{\partial f_1}{\partial x_1} = 0 \quad \text{and} \quad \frac{\partial f_2}{\partial x_2} = -\frac{B}{M}$$

Thus, we should choose step size h according to the following conditions:

$$h_1 < \frac{2}{\left|\frac{\partial f_1}{\partial x_1}\right|} < \infty$$

$$h_2 < \frac{2}{\left|\frac{\partial f_2}{\partial x_2}\right|} = \frac{2}{\left(\frac{B}{M}\right)_{max}} = 0.2$$

where $h_1 < \infty$ indicates a don't-care case. Therefore, $h=h_2<0.2$ is the only guideline we have to follow. Let's choose $h=0.1$. The BASIC program is shown in listing 1. You specify the B/M value, and the solution is printed out immediately.

You now have a powerful computer tool for solving ordinary differential equations of the nth order. Most engineering problems are represented by ordinary differential equations. You can sit down and relax now; let your computer do the engineering design work.■

Reference

1. Carnahan, B, H A Luther, and J O Wilkes. *Applied Numerical Methods* New York: John Wiley & Sons Inc, 1969, pages 344 through 365.

Build a Versatile Keyboard Interface for the S-100

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One of the first decisions you confront as the builder or purchaser of a microcomputer is how to communicate with it. There are three options:

- Use the front panel (if one exists). This is so slow, awkward, and error-prone that it merits no further discussion.
- Interface a video terminal or teletypewriter to the computer, usually by means of a serial I/O (input/output) port. This solution is easy to implement, but is often quite expensive.
- Interface a keyboard to the computer for input and use a video display processor driving a television monitor for output. Since it uses the intelligence of the microprocessor instead of duplicating it, this method is lower in cost and superior in flexibility when compared to a stand-alone terminal.

One goal in building my S-100 system was the development of hardware and software to provide all the capabilities of an intelligent text-editing terminal that could be used to communicate with a mainframe time-sharing system. The third alternative was clearly the way to go. I discovered that while suitable video processors are readily available, keyboards are more of a problem. The only one I found was a surplus keyboard unit.

The keyboard I chose was manufactured by Clare-Pendar. This and very similar keyboards are available from several sources. It will output the full 7-bit ASCII character set and has both a normal shift lock and an uppercase lock that affects only the alphabetic characters and a few special characters—putting the keyboard into a 6-bit ASCII or TTY mode. It generates a positive-going strobe signal whenever a character-generating key is pressed. Several special function keys are provided, including Repeat and Break keys; however, these keys only ground their associated output lines. The keyboard uses a MOS (metal-oxide semiconductor) encoder device and requires −12 VDC and +5 VDC.

Keyboard Interface

There is a significant reason why a standard parallel I/O board cannot provide an adequate interface to this keyboard. A standard handshaking parallel-input port issues a *busy* signal when it is waiting for the processor to accept a character in its buffer. If a keyboard that does not have a *busy* input outputs another character during this time, the contents of the input buffer will be changed. In most systems, this does not actually occur, since the processor has no trouble keeping up with a human operator. However, in an interrupt driven real-time system, the keyboard input process may be preempted by a higher-priority process and thus may be unable to handle characters as fast as they are typed. In such a circumstance, the keyboard must be locked out until the processor is able to accept input; otherwise, characters will be skipped.

The inverse problem is more likely when mating a surplus keyboard to a microcomputer: if the key signal lasts longer than it takes the processor to read a character in the buffer, this character will be read over and over until the signal terminates. Both of these problems are avoided if the busy signal clears the key signal immediately and blocks any subsequent key signals until the processor reads the character. Since most keyboards do not provide such a facility, it must be provided by the interface.

Since my Clare-Pendar keyboard has no on-board repeat oscillator, this must also be included in the interface. If the Repeat key is held down while any character-generating key is pressed, I wanted that character to be repeated until the key is released.

Finally, I wanted the Break key to be operational, since some timesharing systems take special action on sensing a Break. Break is not a control character; on a terminal with a standard current loop interface, it open circuits the current loop as long as it is pressed. For an RS-232C interface, Break forces the transmit line to a space condition as long as it is pressed. Thus, it is necessary for software to sense when the Break key is pressed and released. The serial communication interface I use is based on a 6850 ACIA (asynchronous communications interface adapter), and this software outputs the appropriate code to the device control register to cause a Break (space) level to be transmitted when the Break key is first pressed and then resets the control register when the key is released.

For the reasons outlined above, I designed and built a special-purpose keyboard interface. It is basically a standard parallel input port, but it

The keyboard is addressed as two adjacent I/O channels; the control/status channel is the even address, while the data channel is the odd address.

also handles the busy signal on board, incorporates a repeat oscillator, allows the processor to ascertain the status of the Break key, and provides both +5 VDC and −12 VDC to the keyboard. I also decided to make provision for connecting a paper-tape reader in place of the keyboard in order to load software supplied on that medium (rare though it is these days).

Software Interface

The keyboard is addressed as two adjacent I/O channels; the control/status channel is the even address, while the data channel is the odd address. Any pair of addresses may be chosen by appropriate strapping of true or inverted A1 through A7 address lines to the inputs of IC10 (see figure 1). The true address signal is used if the corresponding bit in the chosen address is a 1 and the inverted signal is used if the bit is a 0.

Output to the control/status channel is used to enable or disable interrupts from the interface. If bit 0 is a 1, interrupts are enabled; if it is a 0, interrupts are disabled. The rest of the bits are ignored. Interrupts are also disabled when power is first applied. If enabled, an interrupt signal is generated whenever a character is output by the keyboard and is available to the processor, or while the Break key is pressed. This signal may be strapped to the interrupt line ($\overline{INT}$) or any of the vectored interrupt lines ($\overline{VI0}$ - $\overline{VI7}$) if a vectored interrupt controller is used.

Input from the control/status channel enables the processor to read the keyboard status register. Bit 0 is a 1 whenever an interrupt would be

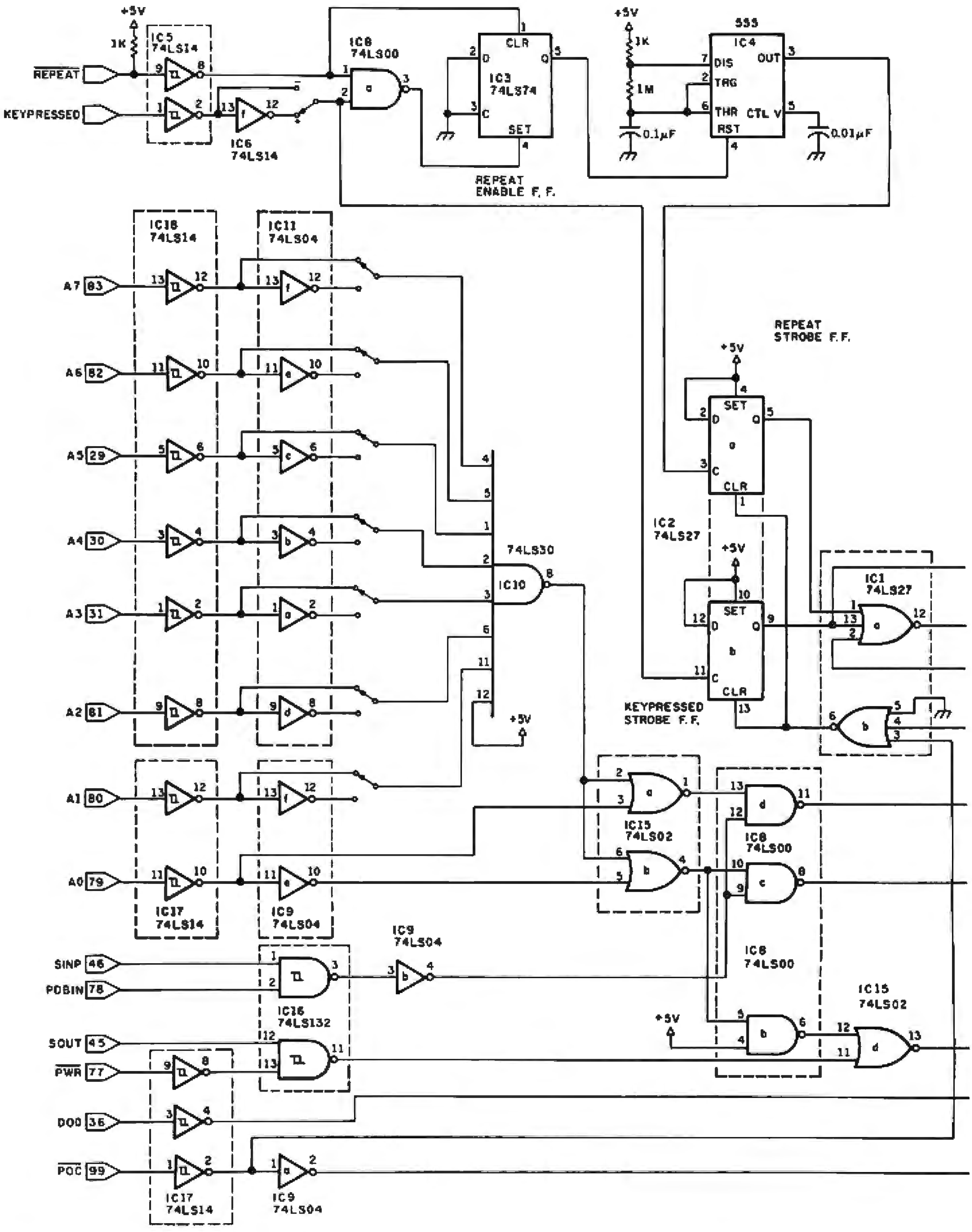
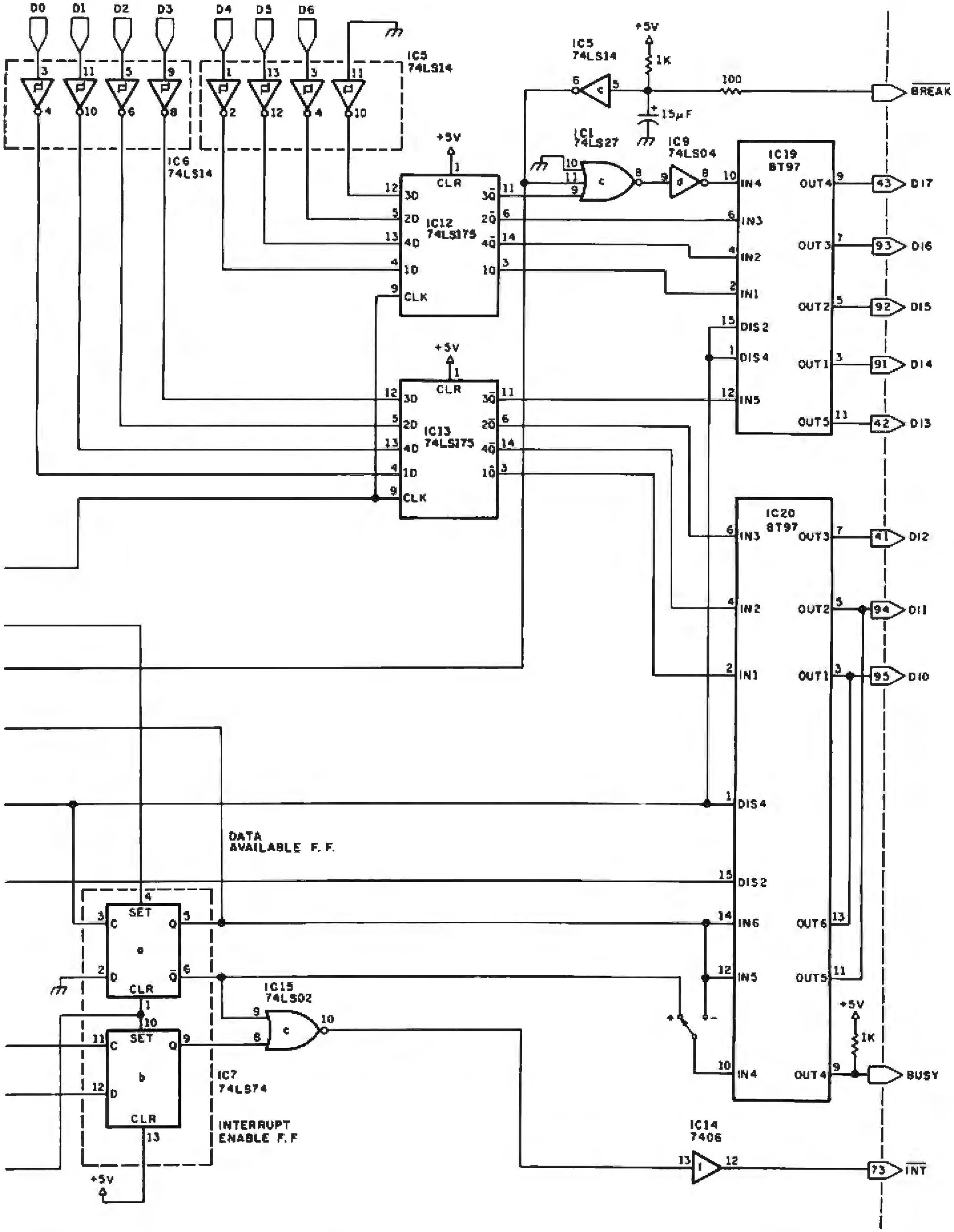


Figure 1: *Schematic diagram for the S-100 keyboard interface. The address jumpers shown are for channels 0 and 1. Keypressed and busy signals may be active high (+ jumper) or active low (− jumper). If a vectored interrupt board is used, the interrupt signal may be jumpered to the processor interrupt line ($\overline{INT}$) or any of the vectored interrupt lines ($\overline{VI0}$ through $\overline{VI7}$). The interrupt sig-*



nal should be left unconnected if interrupts are not used. Data line D7 should be connected to ground inside the keyboard cable 25-pin plug. If a paper-tape reader is connected in place of the keyboard, D7 is used for the high-order data bit. (See power connections on page 404.)

Number	Type	+5 V	GND
IC1	74LS27	14	7
IC2	74LS74	14	7
IC3	74LS74	14	7
IC4	555	8	1
IC5	74LS14	14	7
IC6	74LS14	14	7
IC7	74LS74	14	7
IC8	74LS00	14	7
IC9	74LS04	14	7
IC10	74LS30	14	7
IC11	74LS04	14	7
IC12	74LS175	16	8
IC13	74LS175	16	8
IC14	7406	14	7
IC15	74LS02	14	7
IC16	74LS132	14	7
IC17	74LS14	14	7
IC18	74LS14	14	7
IC19	8T97	16	8
IC20	8T97	16	8
IC21	LM340T-5	—	—

Power connections for figure 1.

generated if enabled, making possible program input/output.

When a character is available, the processor reads it with an input from the data channel. Output to the data channel has no function.

The keyboard generates only 7 bits of data, so the high-order bit 7 of the data channel is used to indicate the status of the Break key; it is a 1 while the Break key is pressed.

A simple keyboard device handler for an 8080-based system is shown in listing 1. It is written so that the calling program can decide what to do if no character is available. In that case, the routine returns with the 0 flag set. If the Break key is pressed, the routine returns with the carry flag set. If a character is available, neither flag is set, and the routine returns with the character in the accumulator.

Listing 2 shows a fragment of a terminal emulator program that inputs characters by calling the keyboard device handler, loops until a character is available, and takes appropriate action when the Break key is pressed.

Listing 1: *A keyboard device handler for an 8080-based system. Utilizing program I/O, this routine returns with a 0 flag set if no character is available or the carry flag set if the Break key is pressed. If neither condition is true, the character is returned to the accumulator.*

```
KBSTAT   EQU   0          ;KEYBOARD STATUS CHANNEL
KBDATA   EQU   KBSTAT+1   ;KEYBOARD DATA CHANNEL
KBD:     IN    KBSTAT     ;INPUT KEYBOARD STATUS
         ANI   1          ;IF NO CHARACTER AVAILABLE, RETURN WITH
         RZ               ;ZERO FLAG SET, CARRY FLAG CLEARED
         IN    KBDATA     ;INPUT KEYBOARD DATA
         RAL              ;IF BREAK KEY DEPRESSED,
         RC               ;RETURN WITH CARRY FLAG SET,
         RAR              ;ELSE RETURN WITH CHARACTER IN
         RET              ;ACCUMULATOR
```

Listing 2: *Example program using keyboard input. This is a fragment of a terminal emulator program which reads characters from the keyboard by calling the keyboard device handler and looping until a character is available. It also takes the appropriate action when the Break key is pressed.*

```
         .
         .
         .
LOOP:    CALL  KBD        ;WAIT FOR CHARACTER FROM KEYBOARD
         JZ    LOOP
         JC    BREAK      ;GO HANDLE BREAK
         .
         .                ;PROCESS CHARACTER
         .
         JMP   LOOP
BREAK:   .                ;ASSERT BREAK CONDITION
         .
         .
BREAK1:  CALL  KBD        ;WAIT FOR BREAK KEY TO BE RELEASED
         JC    BREAK1
         .
         .                ;CLEAR BREAK CONDITION
         .
         JMP   LOOP
```

Circuit Description

A schematic for the interface is shown in figure 1. All logic, except the 8T97 bus drivers, the 7406 interrupt and Busy driver, and the 555 repeat oscillator, is low power Schottky (74LS). All keyboard and bus inputs have hysteresis receivers (74LS14 or 74LS132 Schmitt triggers) for maximum noise immunity. Bus inputs see only a single 74LS load.

When the keypressed line goes active (high or low, depending on how it is strapped), the Keypressed-Strobe flip-flop is set, clocking a character into the data latches (ICs 12 and 13) and setting the Data-Available flip-flop. The Data Available signal then clears the Keypressed-Strobe flip-flop and holds it cleared until the processor has read the character. Meanwhile, any further Keypressed signals are prevented from changing the data in the latches. No conditioning is provided for the keypressed line since my keyboard generates a clean Keypressed Strobe.

If the repeat line is low when the keypressed line goes active, H-3 goes low, setting the Repeat-Enable flip-flop. The repeat oscillator then can clock the Repeat-Strobe flip-flop, which in turn sets the Data-Available flip-flop. The Data Available signal clears the Repeat-Strobe flip-flop and holds it cleared until the processor has read the character in the data latches. The cycle then repeats approximately 10 times per second, so the character in the data latches is read over and over. When the repeat line goes high, the Repeat-Enable flip-flop is cleared so the oscillator can no longer set the Data-Available flip-flop. Contact bounce when the Repeat key is initially pressed really does not matter, hence the repeat line is not conditioned.

If an input or output operation is made from or to the board, F-8 goes low, causing G-4 to go high if the (odd) control/status channel is selected and causing G-1 to go high if the (even) data channel is selected.

If the control/status channel is

selected, coincidence of PDBIN and SINP causes H-8 to go low, enabling the status drivers so the processor can read the state of the Data-Available flip-flop. Coincidence of $\overline{PWR}$ and SOUT causes G-13 to go high, clocking DO0 into the Interrupt-Enable flip-flop.

If the data channel is selected, coincidence of PDBIN and SINP causes H-11 to go low, enabling the data drivers so the processor can read the latched-keyboard data. The trailing (rising) edge of this signal also clocks a 0 into the Data-Available flip-flop, clearing it.

The Break signal, after conditioning, is ORed with bit 7 of the data latch IC12. The keyboard generates only 7 bits of data, so bit 7 is strapped to ground inside the keyboard connector plug and the processor interprets bit 7 as the Break key. The Break signal is also ORed with the outputs of the Keypressed-Strobe and Repeat-Strobe flip-flops and hence, like them, can set the Data-Available flip-flop.

If a paper-tape reader is connected in place of the keyboard, the Break input is left unconnected so that bit 7 is used for data from the reader. The true or inverted Data Available signal is also available on the busy line T-6 to allow a conventional handshaking interface with the reader.

If the Interrupt-Enable and Data-Available flip-flops are both set, the output T-12 of the interrupt bus driver goes low.

The Power-On Clear signal ($\overline{POC}$) initializes the interface by clearing the Keypressed-Strobe, Repeat-Strobe, Data-Available, and Interrupt-Enable flip-flops.

Construction

I constructed the interface on a Processor Technology wire-wrap prototype board. This is supplied with the LM340T-5 regulator, heat sink, and decoupling capacitors needed for the +5 VDC supply. I constructed a zener-regulated −12 VDC supply in the discrete component area below the heat sink.

Wire-wrap sockets (16-pin) are not supplied with the board and must be obtained separately. Figure 3 shows

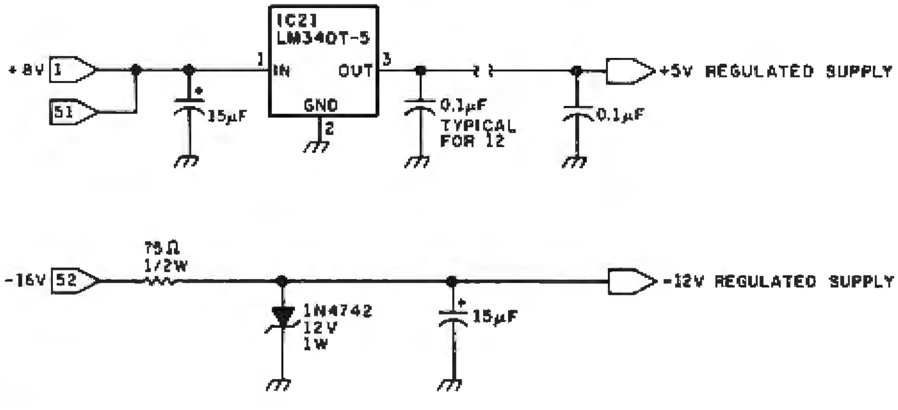


Figure 2: *Schematic diagram of the interface power supply. The 0.1 μf capacitors on the +5 VDC output are ceramic disk despiking capacitors.*

recommended component placement, designed to simplify interconnections and minimize wire lengths. All pins of the lower row of sockets, which provide connections to the bus lines, should be soldered to the board. It is sufficient to solder the four corner pins of the rest of the sockets. The sockets should be oriented so that, when viewed from the *rear* (pin) side of the board, pin 1 is in the upper left-hand corner, pin 8 is soldered to the ground land, and pin 16 is soldered to the +5 VDC land. Between each pair of sockets, a pair of holes is left, one connected to +5 VDC and the other connected to ground. These are intended for the installation of 0.1 μf ceramic disk bypass capacitors for +5 VDC supply despiking. I installed the capacitors at the locations shown in figure 3. (The disk

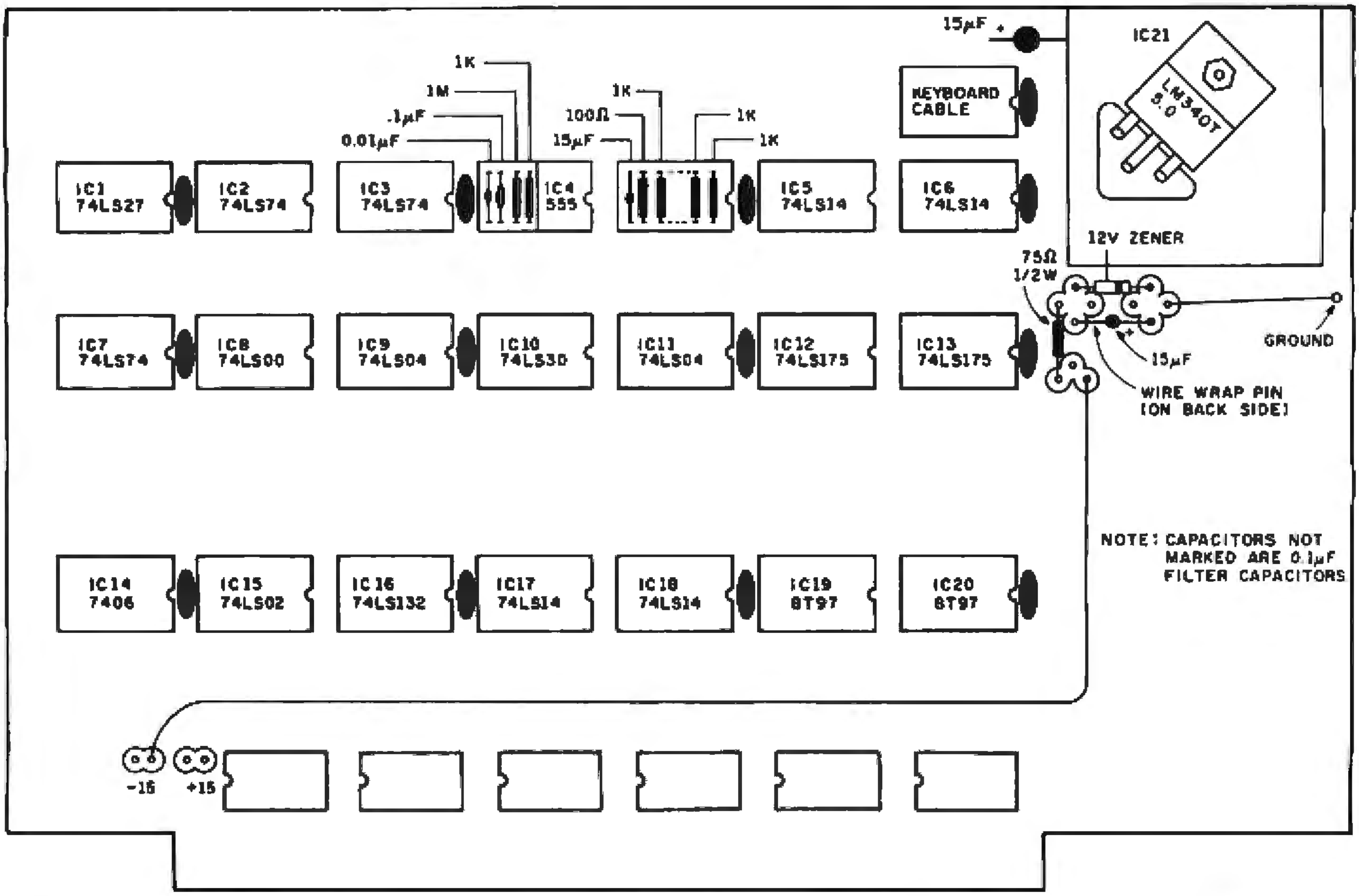


Figure 3: *Component placement for the interface board. The ceramic disk despiking capacitors referred to in figure 2 are shown between the integrated circuit sockets.*

Function	Interface 16-Pin DIP Connector	Back Panel DB-25S Connector	Clare-Pendar Keyboard Edge Connector
KP	2	1	H
BUSY	15	2	—
D0	3	3	3
D1	14	4	C
D2	4	5	4
D3	13	6	D
D4	5	7	B
D5	12	8	1
D6	6	9	A
D7	11	10	—
REPEAT	7	11	5
BREAK	10	12	E
+5 VDC	16	15	9
−12 VDC	1	14	10
GROUND	8	13	8

Table 1: *Pinout connections for the cable between the keyboard and the S-100 interface board.*

capacitors supplied with the board were too large to fit between the sockets and I had to use physically smaller ones.)

All integrated circuits, regardless of the number of pins, are inserted with pin 1 in pin 1 of the 16-pin sockets. It is then necessary to install a short wire-wrapped jumper from pin 8 (ground) of the socket to pin 7 for 14-pin circuits and to pin 1 for the 8-pin 555.

The discrete timing components for the 555 oscillator, the pull-up resistors for the repeat and busy lines, and the components for the break line conditioning circuit are soldered to two DIP (dual in-line pin) header plugs as shown in figure 3. These plugs are then installed in sockets at the locations shown.

Connections to the keyboard are made through a 16-pin socket. I used a 16-conductor flat cable jumper with a DIP plug at one end to connect this socket to a 25-pin socket (DB-25S) on the computer's back panel. Table 1 shows the pinouts for both sockets. I then made up a 6-foot cable with a 25-pin plug (DB-25P) at one end and a 20-contact printed-circuit edge connector (AMP 582963-2 with 42839-4 pins and a 582501-1 polarizing key) at the other to mate with the keyboard.■

PERT Organization

A Technique for Evaluating Schedules

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The acronym PERT stands for Program Evaluation and Review Technique, a mathematical method used by thousands of computer programmers on both large and small systems to solve one of the basic problems of middle-level managers: how to determine the relative importance of the tasks under their supervision.

Let us define a middle-level manager as a person responsible for a project comprised of many tasks. Various low-level managers, each responsible for one particular task, report to the middle-level manager. (By contrast, the top-level manager is more concerned with deciding which projects to undertake, and formulating policy.) The basic purpose of the middle-level manager is to anticipate possible obstacles and still complete the project on time.

A Typical Problem

In order to more clearly illustrate the middle-level manager's problem, let's be specific and assume that the project is the construction of the fifth floor of a seven-story office building.

The project begins with the forming and the pouring of concrete. The procedure is supposed to take six days, but for some reason it takes seven days. Now the project is a day behind schedule.

At this point, the manager looks at the various tasks: plumbing, spray fireproofing, and so on, and notes that while most of them will require from three to five days, the installation of electrical wiring in the wall will require sixteen days. Accordingly, he hires a few more electricians, and the electrical wiring is installed in fourteen days. Now the project is a day ahead of schedule.

In several ways, the calculation of T2 is the reverse of the calculation of T1

Or is it? After the walls have been wired, the next step involves the lath and plaster, which can't be started until the insulation has been installed. The insulation requires only three days, but that can't progress until the electrical testing has been completed, and that requires three days. Of course, the testing can't begin until the ceiling air ducts and fixtures are in, which takes five days...and so on and so on. The upshot is that the project is still one day behind.

The problem in this example (taken, as is much of the material in this article, from *Fundamentals of Data Structures*, see references) is that the electrical wiring is not a *critical activity* (ie: a task that causes the *entire* project to slip if it falls behind schedule). In fact, in this example the manager should have hired *fewer*, not more, electricians, and allowed the wiring to take as many as twenty-eight days. The extra money could have been used to hire more people for the spray fireproofing and installation of ceiling ducts and fixtures, which *are* critical activities.

But how can the manager determine what is a critical activity and what is not? This is where PERT comes in.

Analyzing Problems with PERT

There are many ways to apply PERT. I will illustrate one simple application. The first step is to *number* each task, or activity, in such a way that they can be performed in numerical order. For example, we cannot require that activity number 7 be finished before activity number 4 is started, for if this is the case, then activity number 4 should be designated

as some number higher than 7. If there are n activities, then they should be numbered from 1 to n.

To adapt our scheme to computer notation, we will now set up a two-dimensional array, called B. If we require that for each pair of activity numbers I and J, I be finished before J can start, we set B(I,J) = 1. Otherwise, we set B(I,J) = 0. (If we use a version of BASIC that does not allow double subscripts for arrays, or if we use assembly language, we can employ the following trick: set up a single array A, containing n^2 elements, where n is the number of activities, and then refer to each B(I,J) array element as A(K), where we have assigned K = $n \times (I-1)+J$ before referring to A(K). Thus, elements B(1,1) through B(1,n) are represented as A(1) through A(n); B(2,1) through B(2,n) as A(n+1) through A(2n); and so on.)

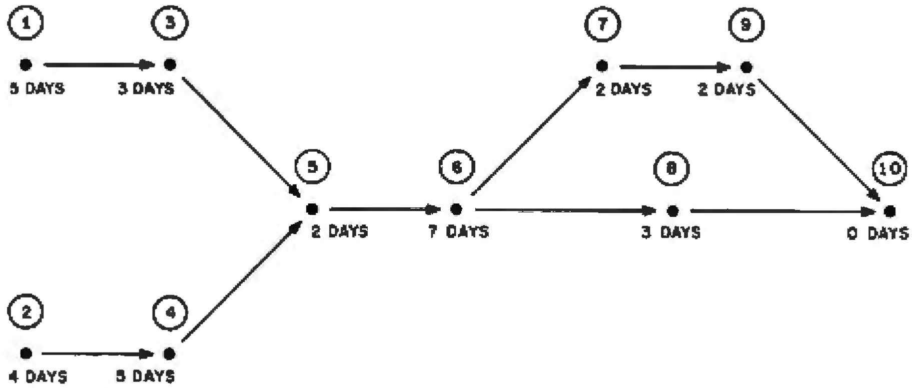


Figure 1: *Typical project containing ten tasks, or activities. Each task requires a certain number of days for completion and can be begun only when the preceding tasks have been finished.*

We initialize this double array to all zeros and then input various pairs of numbers I and J, where we want to set B(I,J) = 1 according to the above rule. We also set up another array T, such that T(I) is the amount of time taken by activity number I. If T(7) = 5, then activity number 7 takes five days to complete. (Actually it could be five weeks, or even five hours, just as long as the same units are used throughout the array T.) All the numbers T(I), as I varies from 1 to n, must be entered.

Now we have all the input we need, and we can proceed to calculate which activities are critical. We must first set up an array that we will call T1, such that each element T1(I) is the earliest starting time for the activity number I. If T1(5) = 9, then activity number 5 cannot be started before the ninth day of the project. (From now on, we will assume that all times are given in days.)

A possible reason why T1(5) might equal 9 is revealed in figure 1. The numbers in circles are activity numbers, and we have drawn arrows between activities; all activities linked by incoming arrows must be completed before the next activity can begin. Activity number 1 takes five days, and activity number 3 takes three days. If we look only at the upper part of the diagram, we might think that activity number 5 could start after eight days. However, if we look at the rest of the diagram, we see that we have to perform activity number 2, which takes four days, and then number 4, which takes five days, before we can do number 5. So number 5 cannot, indeed, start until after nine days.

(One confusion that often arises is that if a task requires three days, and it is begun, let us say, on Monday, the task should be finished by Wednesday. Yet Wednesday is two, not three days after Monday. The solution to this paradox is to consider a day as a 24-hour period. If a task is started at 8 am Monday, and it takes three days, we consider it to be finished at 8 am Thursday, although in reality it will be finished by 5 pm Wednesday.)

In figure 1, the arrow drawn between activities I and J corresponds to B(I, J) = 1. Thus we have B(1, 3) = 1 and B(3, 5) = 1. It is debatable whether or not we should set B(1, 5) = 1; after all, activity number 1 must be completed before activity number 5 can begin, but only in an implied sense. In this case, it does not really matter if B(1, 5) = 1. In general, redundant pairs of activities can either be provided as input or left out; the critical-activity calculation will come out the same, regardless.

The calculation of the earliest starting time, T1(I), is performed as I varies from 1 to n. At each stage, we look at all B(K, I), for K less than I, such that B(K, I) = 1. If nothing has to finish before activity number I can start, then we set T1(I) = 0, since activity number I can now clearly start at time zero. In setting up the problem of figure 1, we would set T1(1) = 0 and T1(2) = 0.

If there is *one* array element B(K, I) that satisfies the condition above, then we add T1(K), the earliest time at which activity K can start, to T(K), the time that activity K takes. Thus, in figure 1, in order to calculate T1(3), we would add T1(1) and T(1). We find that activity 1 can start at time zero, and it takes five days. Clearly, activity 3 cannot start until after five days—that is, T1(3) = 5. In the same way, we calculate T1(4) = 4.

If there is *more than one* element B(K, I) that satisfies the condition, then we perform the above calculation several times and choose the *largest* answer. Let us calculate T1(5) as shown in figure 1. We have:

T1(3) = 5
T(3) = 3
T1(3) + T(3) = 8

and

T1(4) = 4
T(4) = 5
T1(4) + T(4) = 9

This is the calculation we made before. One condition is that activity number 5 cannot start until after eight days; the other condition is that activity number 5 cannot start until after nine days. Therefore, it is the ninth-day starting date that is important. In general, there might be three or more cases that we have to consider, and we take the largest of the calculations.

The resulting values of T1(I), for all I, are shown in figure 2. In practical cases, usually the last activity in the project is to clean up, and we cannot clean up before we have finished everything else. In the next calculation, we must assume that the last activity cannot be started before everything else is finished. If this is not the case, we set up a dummy activity, like activity number 10 in figures 1 and 2. This takes no time at all and ends the project.

If T(I) = J, this does not necessarily mean that activity number I must begin at time J. Look at activities 6, 7, 9, and 10 in figure 2, and suppose that

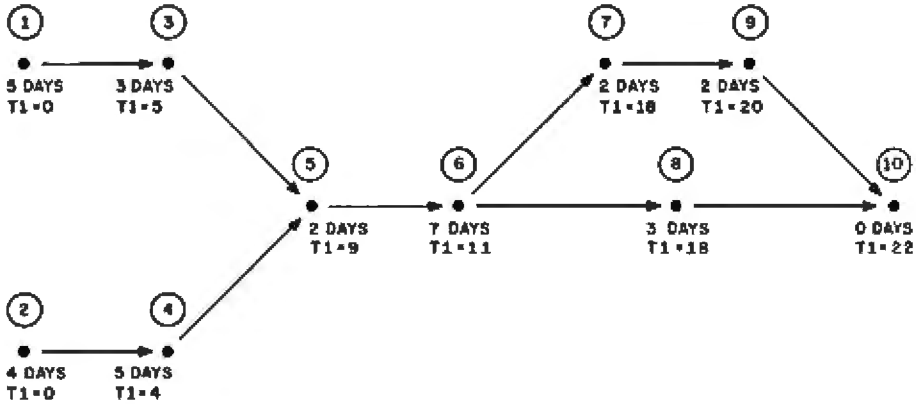


Figure 2: *For each activity in figure 1, T1 (the earliest time that each activity can start) can be calculated according to the scheduled completion times of preceding activities.*

they all start at the times given; that is, on the eleventh, eighteenth, twentieth, and twenty-second days, respectively. Now look at activity number 8. It is *scheduled* to begin on the eighteenth day, but it could also begin on the nineteenth day (because the task takes three days, and by the time it is finished we are up to day twenty-two, which is activity number 10—the end of the project.)

We are now ready to start the next calculation. This time we are calculating a set of values called T2(I), for all I from 1 to *n*, but we will calculate them in reverse order. That is, we will calculate T2(*n*) first, then T2(*n*−1), and so on, and calculate T2(1) last.

To speed up a project, we must accelerate an activity that lies on every critical path

The time T2(I) is the *latest* time that activity number I can *end* without causing the entire project to slip. A moment ago we saw that activity number 8 could occur on either the eighteenth or the nineteenth day, and it would end on either the twenty-first or the twenty-second day. Therefore T2(8) would be 22, because the twenty-second day is the latest time that activity number 8 can end.

Before we see how to calculate T2(I), let us see how we can use it. In our example, we have T1(8) = 18 and T2(8) = 22. What does this mean? It means that activity number 8 *cannot* start before day eighteen, and it *must* finish by day twenty-two. Therefore, this activity cannot take more than four days. In fact, it is supposed to take three days (T(8) = 3), and it can slip by one day, but not more than one day (otherwise, the entire project will slip). In this case, activity number 8 is *not* critical. If it were scheduled to take four days—that is, if T(8) were equal to 4—then it *would* be critical. So as soon as we calculate T2(I) for all I, we will know immediately which activities are critical.

To calculate T2(I), we look at all

B(I, J), for J greater than I, such that B(I, J) = 1. If there are no instances (which, under our assumptions, will happen only for the last activity in the project, ie: I = *n*) we set T2(I) equal to T1(I) + T(I). That is, the last activity must start by time T1(I), and it requires time T(I), so it must finish by time T1(I) + T(I) in order to get the entire project done in the least amount of time that is consistent with the data we have provided about all its various activities.

If there is *one* B(I, J) that satisfies the condition above, then we subtract T(J) (the time that activity J takes) from T2(J), the latest time that activity J can be finished while keeping the project on schedule. Since the values of T2(I) are being calculated in reverse order, we can assume that T2(J) has already been calculated. In the project shown in figure 2, we get the value of T2(9) by subtracting T(11) from T2(11), because activity 10 takes no time, and the answer is 22. We get T2(7) by subtracting T(9) from T2(9), and the answer is 20.

Note what this last answer means. The ninth activity takes two days, and it *must* be done by day twenty-two. This means that it *must* start by day twenty. If we look at figure 2, we can see that this implies that activity number 7 must also be finished by day twenty. In the same way, we calculate T2(8) = 22.

Finally, if there is *more than one* B(I, J) that satisfies the condition, then we perform the above calculation several times and choose the *smallest* answer. For example, if we calculate T2(6) in figure 2, we have:

T2(7) = 20
T(7) = 2
T2(7) − T(7) = 18

and:

T2(8) = 22
T(8) = 3
T2(8) − T(8) = 19

This means that activity number 6 must end by the eighteenth day, and also by the nineteenth day. Therefore, the eighteenth-day deadline is the one we must heed. We can observe a number of ways in which the calculation of T2 is the reverse of the calculation of T1: we go from back to front; we look at B(I,J) instead of B(K,I); we must have J larger than I, instead of K smaller than I; and when there are several calculations at one place, we take the smallest, instead of the largest, of the results.

The resulting values of T2(I), for all I, are shown in figure 3. We can now look at T1(I) and T2(I), for all I, and calculate which activities are critical. As we have noted above, activity number I is critical if T2(I) − T1(I) = T(I); otherwise, it is not. The critical activities in figure 3 are numbers 2, 4, 5, 6, 7, 9, and 10. The noncritical activities are 1, 3, and 8.

We now have the answer to the manager's problem in this case: activ-

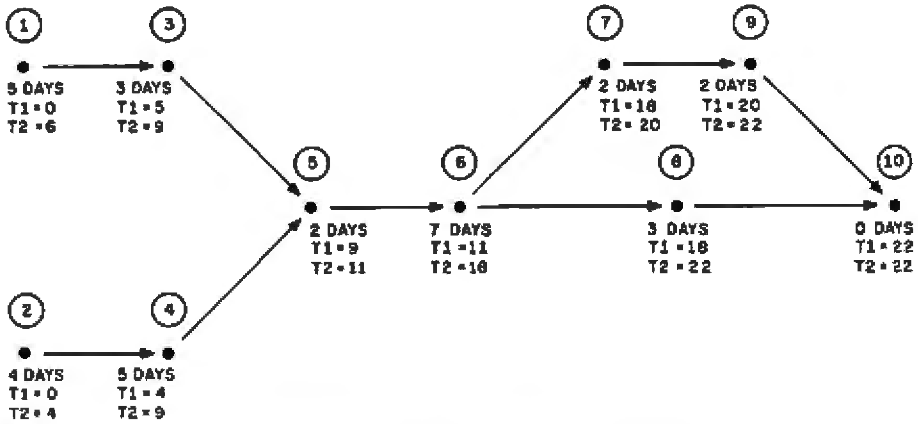


Figure 3: *T2 (the latest time that each activity can be finished without throwing the entire project behind schedule) can be calculated for each activity in the project of figure 1.*

ities 1, 3, and 8 should *not* be accelerated because they will not affect the project's completion time. On the other hand, any one of these three activities could slip by one day without affecting completion time. (In fact, activities 1 and 8, or activities 3 and 8, could both slip, but not both activities 1 and 3.)

The critical activities can all be seen to lie on one path from the beginning to the end of the project. This is called a *critical path*. In general, there might be more than one critical path in a project. If an activity is critical, it cannot slip without affecting project time—that is, if it is on a critical path. On the other hand, speeding up any one activity will not speed up the entire project unless the accelerated activity is on *every* critical path.

Machine Coding Considerations

If the total number of activities is so large that we cannot fit all of the array elements B(I, J) into the number of available words of memory, we may use the following trick. Since each element B(I, J) is either 0 or 1 (such a matrix B is often called a *boolean matrix*), we can put each element into a single bit of a memory location. On an 8-bit machine, working in assembly language, we would represent B(I, J) by first dividing J by 8 and obtaining a quotient of K and a remainder of L. We would then store B(I, J) in the Lth bit of B(I, K), and the dimensions of B would now be n by $n/8$ instead of n by n.

To accomplish this representation, we use an auxiliary table P, such that table element P(1) is the zeroth bit (from the right—ie: in the binary number's units bit), element P(2) is the first bit (ie: the number's 2^1 bit), P(3) is the second bit (ie: 2^2 or 4), and so on. We can set up this table by setting P(1) = 1 and then P(I+1) = 2×P(I) for I = 1 to 7. To set the Lth bit of X, we perform the logical OR of P(L+1) and X, and store it in X; to test the Lth bit of X, we perform the logical AND of P(L+1) and X, and test the zero status flag. On a 16-bit machine, we do the same analysis, substituting 16 for 8.

In integer BASIC, even on an 8-bit machine, each integer is customarily stored in 16 bits. If the logical AND and OR functions are not available in the given dialect of BASIC, or by means of standard library functions, then we can test the Lth bit of X by adding it to itself (that is, shifting it 1 bit to the left) N−1−L times, and seeing whether or not the result is negative. We can set the Lth bit of X by *adding* P(L+1) to X, provided that we know this bit is not set (by testing it as above).

Exploring Further

Further analyses of critical paths or critical activities will be found in Ellis Horowitz and Sartaj Sahni's *Fundamentals of Data Structures*. These authors describe two graphical models of a project—the AOV (activity on vertex) model, in which each vertex of a graph like figure 1 corresponds to an activity, and the AOE (activity on edge) model, in which an activity corresponds to an edge, or arrow between nodes. The critical-path algorithm given there is actually for the AOE model, whereas the one I give here is for the AOV model. The authors also provide a discussion of an algorithm (called *topological sort*) which can be used to renumber all the activities if the numbering that is used does not satisfy our fundamental property of carrying out all activities in the project in their numerical order. ■

Reference

1. Horowitz, Ellis and Sartaj Sahni. *Fundamentals of Data Structures.* Rockville MD: Computer Science Press, 1976

Should the DO Loop Become an Assembly-Language Construct?

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The 1970s saw the inception and growth of microprocessors as well as continuing growth and improvement in the architecture and processing power of minicomputers. Although the architecture of CPUs (central processing units) has varied widely through the years, the majority of the new 16-bit microprocessors have emulated, to various degrees, the stack-pointer architecture once found in the DEC (Digital Equipment Corporation) PDP-11.

The stack pointer is used to control an area in program memory where temporary data and subroutine- and interrupt-return addresses can be stored separately from the main program. The stack-pointer approach has proved useful to programmers because it allows reentrant, nonself-modifying subroutines. This approach can be contrasted with machines (e.g., the DEC PDP-8) where a subroutine return address is saved in the first location of the subroutine proper, which can reside only in programmable memory.

An additional feature now found in most processors is the familiar processor-status register containing flag bits formed from the result of ALU (arithmetic logic unit) operations on data. With conditional branch, jump, jump to subroutine, and return (as well as interrupt) instructions available on the various processors, program loops can become very compact and intricate.

A well-designed instruction set can give the engineer and programmer every degree of freedom and every feature desired. But does it?

An Example

Take the case of the assembly-language program in which a positive binary word in memory is required for the next sequence of instructions. But for various reasons (known only to the programmer), the word may instead be stored as a *negative* value.

In the Motorola 6800, Fairchild F8, and even the Motorola 68000 microprocessors, such a value must be loaded and tested for positive status. If negative status results, the data must be complemented via a branch to the proper code before returning to normal program execution. There has been one processor available for some time, however, that performs the absolute-value conversion with a single instruction: Texas Instruments' TMS-9900.

Obviously, there are other instructions that could make programming tasks far simpler. Disregarding for a moment the desire of manufacturers to minimize microcode requirements to limit the size of silicon wafers, and the argument that some missing instructions can be "worked around" through use of other instruction chains, it is obvious that highly innovative and useful instructions can still be invented by clever users and designers of computers. Users still need more innovative instructions to help relieve the monumental programming requirements of the 1980s. (After all, where would computers be if architecture development stopped with the invention of the subroutine and the carry bit?)

The following discussion will show how one set of "new" instructions (or acceptable variations) can be found scattered, piecemeal, in a number of existing modern processors, but that *no one processor* supplies the user with the entire set. In particular, the first new instruction, requiring merely a modified stack pointer, has yet to be found in a survey of a number of late-model processors. This instruction, along with its mate, allows assembly-language programming of DO loops.

"New" Instructions

For the discussion of these instructions shown in conceptual form in table 1, I ask the reader to assume that the processor has at least one stack pointer, one or more accumulators, and, perhaps, additional main registers. This model, in figure 1, resembles the architecture of the PDP-11 and 6800.

About the Author

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Mnemonic	Function
DO *n*	The address of the instruction following this one (PC+2) is saved on the DO stack, along with the loop-counter value *n*. The DO loop will then begin at the instruction following this one (at PC+2). (See figure 2.)
NXT	The ending instruction of a DO loop. In the DO construct, the value *n* is decremented and tested for 0. If *n* does not equal 0, the execution is resumed at the location saved in the DO stack. If *n* does equal 0, program execution continues at the next instruction after NXT. DO loop nesting is permitted by virtue of stack control.
ABS N	Converts binary value at effective address N to absolute binary value and stores it back in N or in an accumulator. Processor-status-word flag is set if value was originally positive.
ASC N	Converts a 4-bit binary value at effective address N to its ASCII equivalent (0 through F).
BIN N	Tests a value at effective address N to see if it is a legal hexadecimal ASCII character symbol (0 through F). If it is, the character is converted to the 4-bit binary equivalent. If it is not, a processor status flag is set and conversion does not occur.
SRCH *n*, M	Searches for the word or character *n* in a page of memory beginning at effective address M until either the first occurrence of that character or end-of-page. (Page size fixed at some value.) If the search fails, a processor status flag is set. If the search succeeds, the location of the character is saved in a temporary register.
SRCH *n*, −M	Similar to above, but search proceeds in a negative direction from effective address M to end-of-page.

Table 1: *Innovative and useful instructions, some of which are now available to microprocessor users. These instructions are not all available on any one processor.*

It is interesting to consider how these instructions have been implemented in various processors. These data are shown in table 2. The seven instructions listed are not to be construed as the only instructions eligible for consideration. They are presented as thought-provoking examples.

The DO Loop Instructions

Frequent use of nested execution loops (DO . . . CONTINUE loops in FORTRAN, FOR . . . NEXT loops in BASIC) raise the question: Why not allow a DO loop construct in assembly language (i.e., in the architecture of the processor itself)? Conceptually, a processor architecture to accomplish DO loops would take the structure of figure 1b, where a DO pointer addressing a DO stack has been added to a processor of simple architecture resembling the 6800 microprocessor.

The DO stack would function as a conventional stack, except, unlike a conventional stack that saves the next (return) address for a subroutine, the DO stack saves the next (looping) address followed by an additional value *n*. (See figure 2.) The value *n* is the integer number of times the loop is to cycle. The loop is initiated with the DO *n* instruction, but program flow continues inline.

The value *n* could reside in an accumulator or some other processor register rather than residing in program memory immediately after the DO op code. Then a reference to a location or register that contained the address of the operand value would remove the need for self-modifying code if *n* were to be a variable (e.g., DO (*n*) or DO R_n). To show as simply as possible the operation of the DO instruction, the general form DO *n* will be used here.

The DO loop is bounded by an NXT instruction op code. Upon reaching this instruction, the control logic in the processor uses the DO pointer to reference the location of the value *n* on the DO stack. The value *n* is then temporarily pulled and decremented. If the value of *n* is not 0 after the decrement, the new *n* value is pushed back onto the stack, and the next two stack values (D-2 and D-1) are read out as the address to loop back to for further iteration. Figure 2 compares the conventional stack pointer to the new DO pointer in more detail.

(1a)

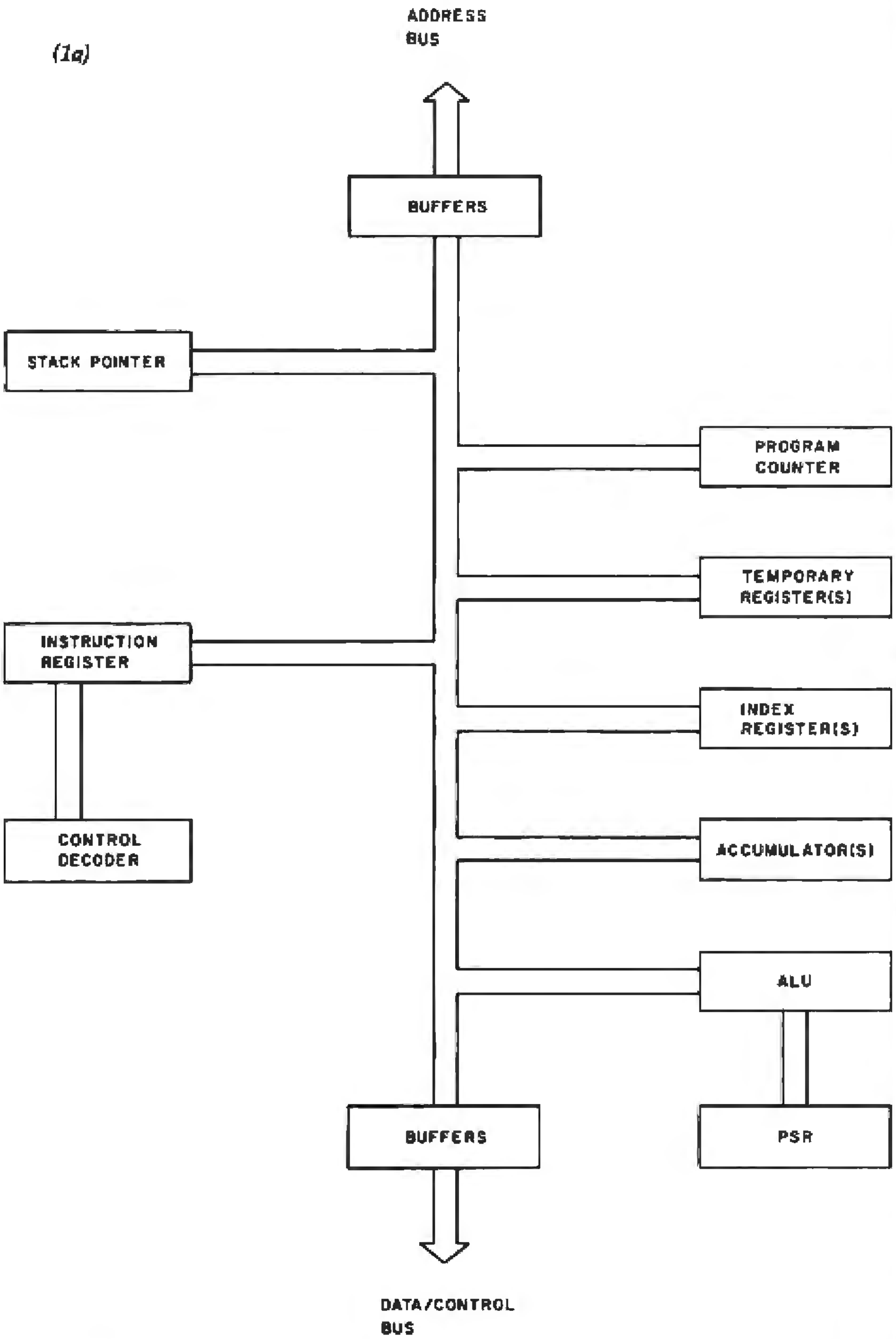


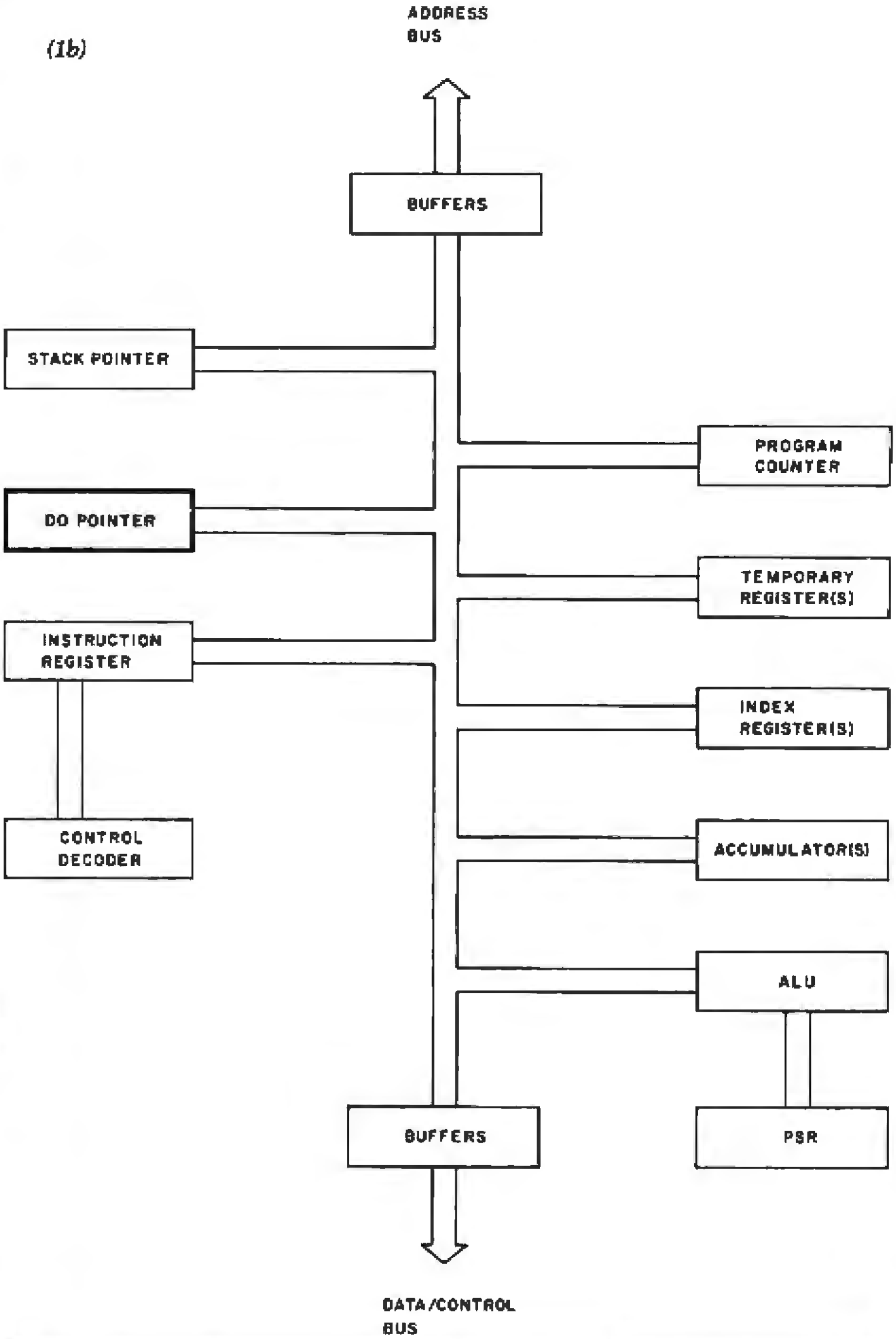
Figure 1: *Block diagram of a typical processor with stack pointer. Figure 1a is based on the 6800 microprocessor; in figure 1b (see page 416), the DO Pointer has been added.*

If the value *n* is 0 after being decremented, however, the DO loop is defined as being completed. The DO pointer is adjusted to its preloop value (*D*) and execution continues with the first instruction after the NXT op code.

DO loops can be nested using these rules. Well-designed DO loops configured under the same nesting rules as FORTRAN or BASIC would not terminate prematurely. The DO pointer could be in error only through procedures that are commonly accepted as illegal in high-level languages or procedures in assembly-language programming similar to illegal exits from subroutines and interrupts.

A DO loop controlled by a DO pointer would then match high-level language requirements and would re-

(1b)



Mnemonic	Present Similar Implementation (and processor)
DO *n*	none(?)
NXT	DB_{cc} (Motorola 68000) LOOPE/LOOPNE (Intel 8086)
ABS N	ABS N (Texas Instruments TMS 9900)
ASC N BIN N	XLAT ASCII TBL (Intel 8086)
SRCH *n*, M SRCH *n*, −m	SEAF O, Md (Advanced Micro Devices HEX-29) LOCC n, L, M (DEC VAX 11/780) CPIR (CPDR) (Zilog Z80) SCAZ TXT LINE (Intel 8086)

Table 2: *Present implementations of "new" instructions.*

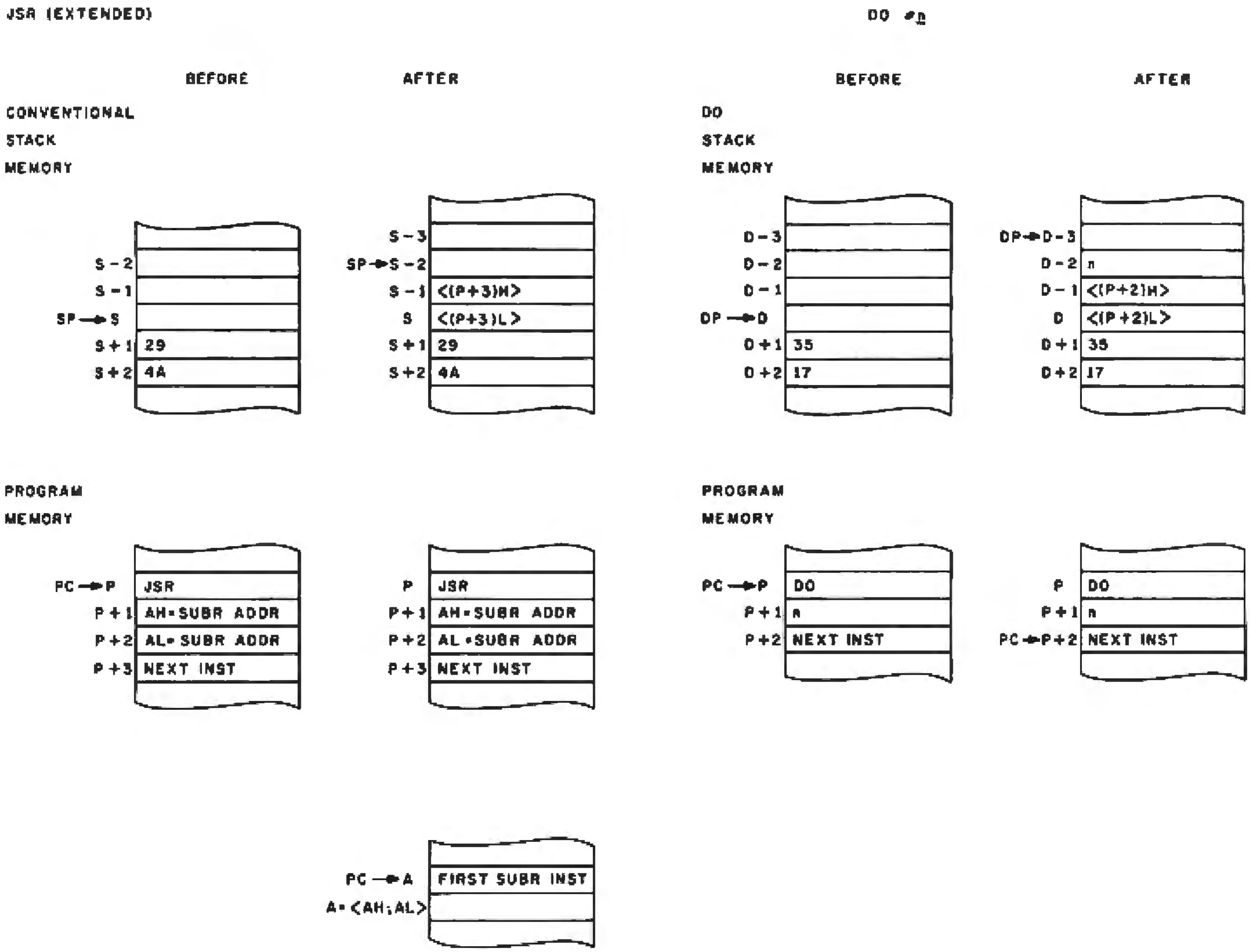


Figure 2: *Comparison of a Jump to Subroutine instruction with proposed DO instruction. This diagrams the positions of the SP (stack pointer) relative to the PC (program counter) and the DP (DO Pointer) relative to the PC—both before and after the respective instructions have been executed (based on the architecture of the Motorola 6800 microprocessor).*

lieve compiler writers of the burden of performing these operations with long strings of assembly-language instructions. The DO loop would also be made available to assembly-language programmers and microprocessor-hardware engineers.

What about the processors currently competing on the market? In table 2, there is a reference to the DB_{cc} instruction of the 68000 microprocessor, which performs the function of the proposed NXT instruction. But the user is left without the benefits of the automatic stacking operations of the proposed DO Pointer.

Variations

Studies of op-code usage have shown that the DO loop feature I've described could be "appended" to common op codes, such as ADD, SUB, IN, and OUT, so a common function could have the added features of automatic DO pointing. For example:

```
DO n
SUB CONSTANT
NXT
```

would become:

```
SUBDO n, CONSTANT
NXT
```

This approach, however, involves a departure from the regularity desired in modern instruction-set designs.

Single instructions with the loop-and-decrement mode are already available in several forms on the Z80 (LDIR and LDDR for moves; CPIR and CPID for the SRCH function; INIR, INDR, OTIR, and OTDR for input/output; and DJNZe for a function similar to NXT). The Z80 does these without benefit of a true DO pointer and without being able to combine arithmetic instructions and other general functions under one main DO loop.

It *is* feasible (and imperative) that a general DO architecture be included in future processor designs. There is a demonstrable need for the DO architecture, and it has been shown how such operations can be incorporated easily into many of the available architectures.

Summary

Modern processor instruction sets are by no means complete, if complete is defined as providing for all simple, regular instructions that could be of significant value to programmers and engineers. Instead, an all too common complaint is that a few basic instructions are either nonexistent or difficult to find in most processors, and trade-offs in original designs of many processors have left some addressing modes incompletely supported. For example, one popular microprocessor implements branches, jumps, and subroutine jumps, but omits the branch to subroutine that is so useful in writing position-independent code.

It seems that restrictions of semiconductor die size has often "squeezed out" some useful instructions as a one-time cost savings. The result: programmers endlessly emulate desired, but unavailable, instructions with long sequences of other existing instructions. This has proved costly.

The magnitude of the programming tasks to be accomplished in the coming years could be reduced considerably with more useful assembly-language instructions. The challenge of the 1970s was to design newer and better processors. The challenge for the 1980s is to promote the evolution of processors with high-level instruction sets to help alleviate the software-management problem. The DO loop is one example of assembly-language- and processor architecture-related development that should be considered. ■

References

1. *Computer Structures: Readings and Examples.* C Gordon Bell and Allen Newell. McGraw-Hill, 1971.
2. *VAX11/780 Software Handbook.* Digital Equipment Corporation, 1977.
3. *M6800 Microprocessor Application Manual.* Motorola. McGraw-Hill Inc, 1975.
4. *Build a Microcomputer, Chapter VIII, HEX 29.* Advanced Micro Devices, 1979.
5. *9900 Family System Design and Data Book.* Texas Instruments, 1978.
6. *MC68000 Microprocessor Users Manual.* Motorola, 1979.

Apple Pascal Cross-Reference

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Debugging a long or complex program can be made much easier by using reference listing. A utility program can easily generate one from the source code, listing the line numbers of all program statements in which each variable or named constant is used.

Niklaus Wirth developed an efficient binary-tree-search algorithm for this purpose (discussed in his book *Algorithms + Data Structures = Programs*. Englewood Cliffs NJ: Prentice-Hall, 1975). The algorithm was used in the program APPLE3:CROSSREF provided with the Apple Pascal system. I found CROSSREF unsatisfactory in some ways, however, so I took the basic concepts and developed my own version of the cross-reference program, adding features that make the program better suited for use with the Apple Pascal language system.

The new features include:

- ignoring the characters in comments and quoted-string literals
- dividing the source-code and cross-reference listings into pages with titles
- automatically extending the search into separate disk files that contain source code routed to the compiler by the include-file mechanism
- top-down recursive design

The result is a more readable output listing for programs written in Pascal.

My modified version of the Wirth cross-reference-generator program is shown in listing 1, and its own cross-reference table is shown in listing 2.

A disadvantage of the program given here is that the data tables containing the cross-references are stored in memory, thus limiting the size of the input programs that can be processed. An improved version that I have developed stores the tables on disk, allowing cross-referencing of very large programs. You can obtain both the improved version and a spooler program that lets you specify multiple files for printing from my company for $20. A floppy disk containing both source and pseudocode files is provided.■

Interested readers can contact Siro-tech Software Products at (315) 393-2640.

Listing 1: *Apple Pascal cross-reference program based on a similar utility program provided with the Apple Pascal language system. This version includes several useful additions. Note paging and titling of the listing.*

```
(*$I-,R- *)

PROGRAM CROSSREF,

(******************************************************************)
(*                                                               *)
(*  CROSS REFEFENCE GENERATOR USING BINARY TREE                  *)
(*  FROM WIRTH,ALGORITHMS+DATA STRUCTURES=PROGRAMS,P206          *)
(*                                                               *)
(*  MODIFIED 17-SEP-80 BY ROBERT WOODHEAD FROM APPLE3:           *)
(*  CROSSREF PROGRAM.  OPTIMIZED FOR PASCAL TEXTFILE             *)
(*  CROSSREFERENCING  WITH THE FOLLOWING FEATURES                *)
(*                                                               *)
(*  1) LISTING IS PAGED                                          *)
(*  2) CONTENTS OF COMMENTS AND QUOTED STRINGS ARE NOT           *)
```

Listing 1 continued on page 421

Listing 1 continued:

```
(*      INCLUDED IN THE CROSS REFERENCE                      *)
(*   3) PROGRAM WILL FIND AND INCLUDE FILES THAT WOULD      *)
(*      BE INCLUDED BY THE COMPILER INCLUDE MECHANISM       *)
(*   4) PROGRAM CONSIDERABLY CLEANED UP                     *)
(*                                                          *)
(************************************************************)

CONST C1=10;        (* LENGTH OF TOKENS STORED IN LIST    *)
      C2=10;        (* NUMBERS PER LINE  OF  REF LIST     *)
      C3=6;         (* DIGITS PER NUMBER IN  REF LIST     *)
      C4=30000;     (* MAX LINE NUMBER IN PRINTOUT        *)
      LP=50;        (* # OF LINES PAGE (60-6 MARGINS)     *)

TYPE ALPHA=PACKED ARRAY[1..C1] OF CHAR;
     WORDREF=^WORD;
     ITEMREF=^ITEM;
     WORD=RECORD
              KEY: ALPHA;              (* TOKEN                *)
              FIRST,LAST: ITEMREF;     (* LINKEDLIST OF LINES*)
              LEFT,RIGHT: WORDREF      (* TREE POINTERS       *)
           END;
     ITEMREF=PACKED RECORD
                   LNO: 0..C4;         (* LINE NUMBER         *)
                   NEXT: ITEMREF       (* LINK POINTER        *)
                 END;

 VAR ROOT: WORDREF;  (* ROOT TO TREE OF TOKENS           *)
     K: INTEGER;     (* LENGTH OF CURRENT TOKEN          *)
     N: INTEGER;     (* CURRENT LINE NUMBER              *)
     ID: ALPHA;      (* TOKEN BEING PROCESSED            *)
     A: ALPHA;       (* TOKEN BEING BUILT                *)
     CH: CHAR;       (* CURRENT TOKEN CHARACTER          *)
     LINELEN,        (* OF THE CURRENT LINE              *)
     CHARPOS: INTEGER;
     FLEVEL: INTEGER;    (* FILE WE ARE CURRENTLY USING  *)
     LINE: STRING[255];  (* CURRENT LINE BEING PROCESSED *)
     F1,
     F2,
     G: TEXT;        (* INPUT AND OUTPUT TEXTFILES       *)
     TITLE: STRING;  (* TITLE OF PRINTOUT              *)
     SOURCE,         (* INPUT AND OUTPUT FILENAMES     *)
     DEST: STRING[20];

(* PAGER DETERMINES IF A PAGE EJECT IS REQUIRED, AND IF *)
(* SO, IT DOES IT AND PRINTS THE HEADER                 *)

PROCEDURE PAGER;

BEGIN (* PAGER *)

   IF (N MOD LP)=0 THEN
      BEGIN
         WRITELN('<',N:5,'> [',MEMAVAIL:6,']');

         IF N>0 THEN
            BEGIN
               WRITELN(G);
               WRITELN(G);
               WRITELN(G)
            END;
         WRITELN(G);
         WRITELN(G,'XREF LISTING OF FILE ',
```

Listing 1 continued on page 422

Listing 1 continued:

```
                         SOURCE,
                         ' ':(74-9-21-LENGTH(SOURCE)),
                         'PAGE ',
                         ((N DIV LP)+1):4);
              WRITELN(G);
              WRITELN(G ' ' (37-(LENGTH(TITLE) DIV 2)),
                         TITLE);
              WRITELN(G);
              WRITELN(G)
          END;

(* IN CASE YOU ARE WONDERING WHY IT'S 74 AND 37 INSTEAD *)
(* OF 80 AND 40 IN THOSE WRITELNS, IT'S BECAUSE 80 COL  *)
(* PAPER USUALLY WILL HOLD <80 COLS.  THE CHANGES MAKE  *)
(* SURE YOU WILL SEE THE PAGE NUMBERS, ETC              *)

END;  (* PAGER *)

 * GETLINE READS A NEW LINE FROM THE INPUT FILE  IF     *)
 * IT DETECTS AN END OF FILE, IT PRINTS OUT THE XREF    *)

PROCEDURE GETLINE;

 * ENDITALL PAGE EJECTS AND STARTS THE XREF LIST, THEN  *)
 * EXITS THE PROGRAM                                    *)

PROCEDURE ENDITALL;

 * PRINTREE RECURSIVELY CALLS ITSELF TO PRINT THE TREE  *)
 * OF CROSS REFERENCES                                  *

PROCEDURE PRINTTREE(W  WORDREF

(* PRINTWORD PRINTS A SINGLE CROSS REFERENCE            *)

PROCEDURE PRINTWORD(W  WORD ;

VAR
      I   INTEGER
      X   ITEMREF

BEGIN ( PRINTWORD *

    PAGER;
    N =N 1
    WRITE(G   ',W KEY
     =W FIRST
    L =0;

    REPEAT

        IF L=C2 THEN
           BEGIN
              PAGER
              N =N+1;
              WRITELN(G);
              L =0
              WRITE(G,'  ' C1+1 
           END

        L =L+1
        WRITE(G   LNO C3);
          =X^ NEXT;
```

Listing 1 continued:

```
    UNTIL X=NIL;

    WRITELN(G);

END;  (* PRINTWORD *)

BEGIN (* PRINTTREE *)

    IF W<>NIL THEN
       BEGIN
          PRINTTREE(W^.LEFT);
          PRINTWORD(W^);
          PRINTTREE(W^.RIGHT);
       END

END;  (* PRINTTREE *)


BEGIN (* ENDITALL *)

    WHILE (N MOD LP)<>0 DO
       BEGIN
          N:=N+1;
          WRITELN(G)
       END;

    PRINTTREE(ROOT);

    EXIT(PROGRAM)

END;  (* ENDITALL *)

(* ANINCLUDE OPENS THE INCLUDE FILE AND READS   *)
(* IN THE FIRST LINE                            *)

PROCEDURE ANINCLUDE;

VAR
    SOFNAME,
    EOFNAME:INTEGER;     (* CHARACTER POS PTRS   *)
    TNAME:  STRING;      (* TEMP FILE NAME       *)

BEGIN (* ANINCLUDE *)

    SOFNAME:=POS('(*$I ',LINE)+4;

    TNAME:=LINE;
    DELETE(TNAME,1,SOFNAME);

    EOFNAME:=POS('*)',TNAME);

    IF EOFNAME=0 THEN
       EXIT(ANINCLUDE);  (* WAS NOT AN INCLUDE?  *)

    TNAME:=COPY(TNAME,1,EOFNAME-1);

    WRITELN('INCLUDE FILE -- ',TNAME);

    FLEVEL:=2;
    RESET(F2,TNAME);

    IF IORESULT>0 THEN
       BEGIN
          CLOSE(F2);
          FLEVEL:=FLEVEL-1
       END.
```

Listing 1 continued on page 424

Listing 1 continued:

```
   GETLINE                 (* THE FIRST LINE OF FILE *)

END;  (* ANINCLUDE *)

BEGIN (* GETLINE  *)

   IF FLEVEL=2 THEN      (* CHECK AND HANDLE EOF *)
      BEGIN
         IF EOF(F2) THEN(* MOVE BACK TO FILE 1  *)
            BEGIN
               CLOSE(F2);
               FLEVEL:=1
            END
      END
   ELSE
      IF EOF(F1) THEN
         ENDITALL;

   PAGER;
   N:=N+1;

   IF FLEVEL=1 THEN
      READLN(F1,LINE)
   ELSE
      READLN(F2,LINE);

   LINE:=CONCAT(LINE,' ');

   LINELEN:=LENGTH(LINE);
   CHARPOS:=1;
   WRITELN(G,N:3,'- ',LINE);

   IF POS(' (*$I ',LINE)>0 THEN
      IF FLEVEL=1 THEN
         ANINCLUDE;

END;  (* GETLINE  *)

(* READCH IS THE FUNNEL THROUGH WHICH THE REST  *)
(* OF THE PROGRAM GETS CHARACTERS.  IT FILTERS  *)
(* OUT COMMENTS AND QUOTED STRINGS              *)

PROCEDURE READCH;

(* NEXTCHAR ASSIGNS TO CH THE NEXT CHAR IN THE  *)
(* INPUT STREAM                                 *)

PROCEDURE NEXTCHAR;

BEGIN (* NEXTCHAR *)

   WHILE CHARPOS>LINELEN DO (* SKIPS BLANKS *)
      GETLINE;

   CH:=LINE[CHARPOS];
   CHARPOS:=CHARPOS+1

END;  (* NEXTCHAR *)

(* SPANQUOTE SKIPS CHARACTERS UNTIL IT FINDS A  *)
(* QUOTE (') CHARACTER. IT THEN CALLS READCH TO *)
(* READ IN A VALID CHARACTER.  SINCE READCH MAY *)
(* CALL SPANQUOTE OR SPANCOMMENT, THE EFFECT IS *)
(* TO KEEP RECURSIVELY CALLING UNTIL WE ARE NOT *)
(* IN A COMMENT OR A QUOTE!                     *)
```

Listing 1 continued:

```
 (*                                             *)
 (* PS  DONT YOU JUST LOVE RECURSION!           *)

 PROCEDURE SPANQUOTE;

 BEGIN (* SPANQUOTE *)

    REPEAT
       NEXTCHAR
    UNTIL CH='''';

    READCH

 END;  (* SPANQUOTE *)

 (* SPANCOMMENT DOES A SIMILAR DASTARDLY THING   *)
 (* AS SPANQUOTE   ONE COMPLICATION IS THAT WE   *)
 (* HAVE TO LOOK OUT FOR THINGS COMMENTS LIKE    *)
 (** *)
 (* **)
 (***)
 (* THIS IS DONE BY A WHILE INSIDE A REPEAT      *)

 PROCEDURE SPANCOMMENT;

 BEGIN (* SPANCOMMENT *)

    NEXTCHAR;  (* FLUSH THE * OF THE LEADING PAREN*)
    NEXTCHAR;  (* GET THE FIRST CHAR TO LOOK AT   *)
    REPEAT
       WHILE CH<>'*' DO (* FIND AN ASTERI        *)
          NEXTCHAR;
       NEXTCHAR      (* GET THE CHARACTER AFTER  *)
    UNTIL CH=')';    (* IF A ) WE ARE OK, ELSE IT *)
                     (* MAY BE A * SO REPEAT!    *)

    READCH

 END;  (* SPANCOMMENT *)

 BEGIN (* READCH *)

    NEXTCHAR                  (* READ THE CHARACTER   *)

    IF CH='''' THEN           (* SKIP IF NEEDED       *)
       SPANQUOTE
    ELSE
       IF CH='(' THEN
          IF CHARPOS<=LINELEN THEN
             IF LINE[CHARPOS]='*' THEN
                SPANCOMMENT;

 END;  (* READCH *)

 (* PROCEDURE SEARCH WILL SEARCH FOR THE TOKEN   *)
 (* IN ID  AND IF FOUND, INSERT THE LINE# IN ITS *)
 (* LINKED LIST   OTHERWISE IT WILL CREATE IT    *)

 PROCEDURE SEARCH(VAR W1: WORDREF);

 VAR
    W: WORDREF;
    X: ITEMREF;

 BEGIN
```

Listing 1 continued on page 426

Listing 1 continued:

```
    W:=W1;          (* ROOT OF BINARY (SUB)TREE      *)

    IF W=NIL THEN
       BEGIN       (* IF (SUB)TREE IS NIL, CREATE  *)
          NEW(W); (* WORD RECORD                   *)
          NEW(X); (* AND LINE# RECORD              *
          WITH W^ DO
             BEGIN
                KEY:=ID  (* STUFF IN THE DATA     *)
                LEFT:=NIL;
                RIGHT:=NIL;
                FIRST:=X;
                LAST:=X;
             END
          X^.LNO:=N
          X^.NEXT:=NIL
          W1:=W;
       END
    ELSE              (* NON EMPTY TREE               *)
       IF ID<W^.KEY THEN
          SEARCH(W^.LEFT) (* RECURSIVE SEARCH!     *)
       ELSE
          IF ID>W^.KEY THEN
             SEARCH(W^.RIGHT) (* AND AGAIN          *)
          ELSE
             BEGIN (* FOUND IT, ADD DATA            *)
                NEW(X);
                X^.LNO:=N;
                X^.NEXT:=NIL;
                W^.LAST^.NEXT:=X;
                W^.LAST:=X;
             END;

 END; (* SEARCH *)


 BEGIN (* MAIN *)

    ROOT:=NIL; (* EMPTY TREE TO START                          *)
    FLEVEL:=1  (* ON FIRST FILE AT THE START                   *)
    N:=0

    WRITELN(CHR(12),'MODIFIED XREF PROGRAM - 17-SEP-80 BY RJW');
    WRITELN;
    WRITELN('ENTER A TITLE FOR YOUR XREF BELOW:');
    WRITELN;
    READLN(TITLE);
    WRITELN;
    REPEAT
       WRITE('SOURCE FILE ? >');
       READLN(SOURCE);
       IF POS('.',SOURCE)=0 THEN SOURCE:=CONCAT(SOURCE,'.TEXT');
       RESET(F1,SOURCE)
    UNTIL IORESULT=0;

    REPEAT
       WRITE('DEST   FILE ? >');
       READLN(DEST)
       REWRITE(G,DEST)
    UNTIL IORESULT=0

    WRITELN;
    WRITELN(' LINE#  [MEMORY]')
    WRITELN(' -----   ------');

    GETLINE      (* INITIALIZE THE SYSTEM                      *)

```

Listing 1 continued:

```
    REPEAT         (* FOREVER MORE                    *)

       REPEAT    (* FIND 1ST CHAR IN A TOKEN          *)
          READCH;
       UNTIL CH IN ['A'..'Z','a'..'z','0'..'9'];

       K:=0;     (* ZERO LENGTH OF TOKEN AND TOKEN    *)

       FILLCHAR(A,SIZEOF(A),' ');

       REPEAT    (* FILL UP TOKEN                     *)

          IF K<C1 THEN
             BEGIN          (* ADD CHAR TO TOKEN      *)
                K:=K+1;
                A[K]:=CH;
             END;

          READCH;           (* GET NEXT CHAR IN TOKEN *)

       UNTIL NOT(CH IN ['A'..'Z','a'..'z','0'..'9']);

       ID:=A;               (* INSERT TOKEN INTO TREE *)
       SEARCH(ROOT);

    UNTIL FALSE             (* WILL HIT EOF IN GETLINE *)

 END
```

Listing 2: *Table of the cross-reference generator as produced by the program in listing 1.*

XREF OF XREF

0	38	66	70	125	134	162	193	203	241	380
	391	393	399	413						
1	29	81	122	132	135	138	164	189	196	196
	206	220	228	230	238	242	264	379	421	
10	23	24								
12	382									
2	83	200	215							
20	57									
21	79									
255	51									
30000	26									
37	83									
4	81	186								
5	68									
57	27									
6	25	68								
74	79									
9	79									
A	46	415	415	422	429					
ALPHA	29	33	45	46						
ANINCLUDE	177	194	243							
ARRAY	29									
BEGIN	64	67	71	119	130	148	151	160	163	184
	204	213	216	218	258	279	299	314	338	343

Listing 2 continued on page 428

Listing 2 continued:

```
               347  365  376  420
C1              23   29  135  419
C2              24  129
C3              25  139  239
C4              26   38
CH              47  263  283  304  307  318  321  411  422  427
CHAR            29   47
CHARPOS         49  238  260  263  264  264  322  323
CHR            382
CLOSE          205  219
CONCAT         235  391
CONST           23
COPY           196
CROSSREF         3
DELETE         189
DEST            57  397  398
DIV             81   83
DO             162  260  304  346
ELSE           223  232  320  358  361  364
END             36   40   75   87   94  136  146  155  157  166
               172  207  211  221  222  245  266  287  312  326
               353  357  371  373  423  434
ENDITALL       104  225
EOF            217  224
EOFNAME        181  191  193  196
EXIT           170  194
F1              52  224  231  392
F2              53  201  205  217  219  233
FALSE          432
FILLCHAR       415
FIRST           34  124  351
FLEVEL          50  200  206  206  215  220  230  242  379
G               54   72   73   74   76   77   82   83   85   86
               123  133  135  139  144  165  239  398
GETLINE         99  209  261  405
ID              45  348  359  362  429
IF              66   70  129  150  193  203  215  217  224  230
               241  242  318  321  322  323  342  359  362  391
               419
IN             411  427
INTEGER         43   44   49   50  116  181
IORESULT       203  393  399
ITEM            31   37
ITEMREF         31   34   39  117  336
K               43  413  419  421  421  422
KEY             33  123  348  359  362
L              116  125  129  134  138  138
LAST            34  352  369  370
LEFT            35  152  349  360
LENGTH          79   83  237
LINE            51  186  188  231  233  235  235  237  239  241
               263  323
LINELEN         48  237  260  322
LNO             38  139  354  367
```

```
LP            27    66    81   162
MEMAVAIL      68
MOD           66   162
N             44    66    68    70    81   122   122   132   132   162
             164   164   228   228   239   354   367   380
NEW          344   345   366
NEXT          39   140   355   368   369
NEXTCHAR     256   282   301   302   305   306   316
NIL          142   150   342   349   350   355   368   378
NOT          427
OF            29
PACKED        29    37
PAGER         62   121   131   227
POS          186   191   241   391
PRINTTREE    109   152   154   163
PRINTWORD    113   153
PROCEDURE     62    99   104   109   113   177   251   256   277   297
             332
PROGRAM        3   170
READCH       251   285   310   410   425
READLN       231   233   386   390   397
RECORD        32    37
REPEAT       127   281   303   388   395   407   409   417
RESET        201   392
REWRITE      398
RIGHT         35   154   350   363
ROOT          42   168   378   430
SEARCH       332   360   363   430
SIZEOF       415
SOFNAME      180   186   189
SOURCE        56    78    79   390   391   391   391   392
SPANCOMMEN   297   324
SPANQUOTE    277   319
STRING        51    55    57   182
TEXT          54
THEN          66    70   129   150   193   203   215   217   224   230

             241   242   318   321   322   323   342   359   362   391
             419
TITLE         55    83    84   386
TNAME        182   188   189   191   196   196   198   201
TYPE          29
UNTIL        142   283   307   393   399   411   427   432
VAR           42   115   179   332   334
W            109   113   123   124   150   152   153   154   335   340
             342   344   346   356   359   360   362   363   369   370
W1           332   340   356
WHILE        162   260   304
WITH         346
WORD          30    32   113
WORDREF       30    35    42   109   332   335
WRITE        123   135   139   389   396
WRITELN       68    72    73    74    76    77    82    83    85    86
             133   144   165   198   239   382   383   384   385   387
             401   402   403
X            117   124   139   140   140   142   336   345   351   352
             354   355   366   367   368   369   370
```

Multiple Regression for the TRS-80

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Within the context of a large number of scientific and technological problems it is necessary to be able to predict a score or value of a variable (Y) from one or more *predictors* (Xs). One method commonly used to accomplish this feat is *multiple linear regression.*

This article deals primarily with converting the mathematics of linear regression into a general-purpose BASIC computer program; therefore, only a very brief discussion of the mathematics is presented. Readers should consult the references for this article for a detailed treatment of multiple linear regression.

The fundamental equation for linear regression using a single predictor is:

$$Y' = a + bx$$

where Y' (Y prime) constitutes the predicted value(s) of the *dependent* variable; X is the predictor or *independent* variable; a the intercept constant; and b the regression coefficient. Suffice it to say, at this point, that multiple regression is an extension of simple linear regression:

$$Y' = a + b_1X_1 + b_2X_2 + \cdots + b_nX_n$$

where $X_1 \ldots X_n$ constitutes a set of predictors and $b_1 \ldots b_n$ a set of regression coefficients.

The primary problem in computing a regression lies in determining values for a and b. One formula that may be used to calculate a is:

$$a = \overline{Y} - b\overline{X}$$

where $\overline{Y}$ (Y-bar) and $\overline{X}$ (X-bar) are the mean values for Y and X. As with the prediction formula, there is a straightforward extension to the multivariate case:

$$a = \overline{Y} - b_1\overline{X}_1 - b_2\overline{X}_2 - \cdots - b_n\overline{X}_n$$

One of the primary problems, then, is to solve for the *b*s so that we may calculate the equation.

For one or two independent variables, the calculations for the regression coefficients are straightforward, but with more than two independent variables it is useful to use a computer. It turns out that to obtain the coefficients, we need to solve a set of simultaneous equations. The easiest way to do the arithmetic is with *matrix* algebra.

In order to obtain all the coefficients we need, we can use the following formula (boldface letters denote matrices):

$$\mathbf{B} = \mathbf{RR}^{-1} \times \mathbf{RY}$$

where **B** is a vector (in BASIC, a one-dimensional array), $\mathbf{RR}^{-1}$ is the inverse of the matrix (in BASIC, a two-dimensional array) of correlations between all of the independent variables taken two at a time; and **RY** is a vector of correlation coefficients of each independent variable with the dependent variable. (A correlation coefficient is a measure of the extent to which two variables vary together and, in the two-variable case, is identical to the "standardized" regression coefficient b^* [*b*-star].) The vector **B** has as its elements these coefficients, or b^*s (*b*-stars). The b^*s can be turned into *b*s through the use of the following formula:

$$b_j = b^*_j\,(s_y/s_j)$$

where s_y is the standard deviation of the dependent variable and s_j is the standard deviation of each *j*th independent variable. This article does not propose to explain matrix algebra, so suffice it to say that the computations for inverting matrices can be found in the book by Kerlinger and Pedhazur (reference 3) and in the articles by Adler (references 1 and 2).

In interpreting the results of regression, several additional statistics are useful. The first of these is the coefficient of multiple correlation, which is simply the correlation between the observed and predicted Y values (usually designated by the capital letter R). The proportion of variance in the dependent variable explained by the set of independent variables is given by the square of R. The significance of R^2 can be calculated using an *F*-test. It turns out that once we have accomplished the matrix arithmetic described above, R^2 can be easily calculated:

$$R^2 = b^*_1r_{y1} + b^*_2r_{y2} + \cdots + b^*_nr_{yn}$$

and $R = \sqrt{R^2}$. The *F*-test is also a straightforward calculation:

$$F = \frac{R^2/k}{(1 - R^2)/(N - k - 1)}$$

where k is the number of independent variables and N is the number of observations. F can be tested for the probability of occurrence by con-

sulting a table of F values, or by computation as in the program described. Now let's turn the arithmetic into a useful BASIC program.

Program Description

When doing statistical programming it is often desirable to produce a program that has general applicability to a wide range of data. Indeed, for large computers, a number of extensive general-purpose statistical packages are available. Alas, such is not the case for microcomputers. But, the programs provided will run easily on a 16 K-byte Radio Shack TRS-80 Model I Level II computer. Except for the routines used to format the output for the TRS-80 video monitor, no unusual BASIC keywords are used. Later in this article we show how the program might be simplified if BASIC matrix functions were available (they are not for standard TRS-80 BASIC).

Many regression programs combine the routines to generate correlation matrices with the regression calculations. Because there are a number of valuable uses for a "stand-alone" correlation program, I have provided two separate programs; data for the second is transferred by an output file from the first. The program in listing 1 generates a correlation matrix from keyboard or tape input. On option, the matrix can be saved on tape. The program in listing 2 calculates regression. It would be easy to substitute disk I/O (input/output) for tape I/O. Both programs consist of a main calling pro-

Text continued on page 445

Listing 1: *The correlation-matrix program (1a) and a test run (1b). Written in BASIC for the Radio Shack TRS-80 Model I Level II, this program provides a "stand-alone" correlation matrix that may be saved on cassette tape.*

```
1000 ' CORRELATION MATRIX PROGRAM
1010 CLEAR:DEFINT I-N
1020 ' IF THE ZEROTH ELEMENT OF THE ARRAYS ARE USED, THEN
1030 ' IB MUST = ZERO, ELSE IB=1.  ND=THE MAXIMUM DIMENSION
1040 ' FOR EACH ARRAY (MAX VARIABLES).
1050 IB=0:ND=15
1060 DIM R(ND,ND),A(ND),S(ND)
1070 CLS:PRINT "CORRELATION MATRIX PROGRAM"
1080 PRINT "BY THOMAS WM. MADRON"
1090 PRINT "2132 SAVANNAH TRAIL"
```

Listing 1a continued on page 432

Listing 1a continued:

```
1100 PRINT "DENTON, TX 76201":PRINT
1110 INPUT "ENTER TOTAL NUMBER OF VARIABLES TO BE CORRELATED";NV
1120 IF NV>ND THEN PRINT "*** TOO MANY VARIABLES ***":GOTO 1110
1130 ' NV MUST BE PASSED TO CORL AS A STRING VARIABLE (NV$)
1140 NV$=STR$(NV):N=NV-(1-IB):GOSUB 4000 :NR=N:NC=N:GOSUB 3000
1150 CLS:INPUT "DO YOU WANT THE CORRELATION MATRIX REPRINTED";Y$
1160 IF LEFT$(Y$,1)="Y" THEN GOSUB 3000
1170 CLS:END
3000 ' SUBROUTINE TO PRINT A MATRIX
3010 ' NR=NUMBER OF ROWS.  NC=NUMBER OF COLUMNS.  IF
3020 ' IB=0 THEN NR=NR-1 AND NC=NC-1.  IB=STARTING
3030 ' POINT FOR ARRAYS.
3040 FOR I=IB TO NR STEP 10:IA=I+9:IF IA>=NR THEN IA=NR
3050 FOR J=IB TO NC STEP 9:JA=J+8:IF JA>=NC THEN JA=NC
3060 CLS:PRINT "CORRELATION MATRIX":PRINT TL$
3070 F1$="VAR:":G1$="  ####":F2$="####":G2$=" ##.##"
3080 PRINT F1$;
3090 FOR L=J TO JA:PRINT USING G1$;L+1;:NEXT L:PRINT
3100 FOR L=I TO IA
3110 PRINT USING F2$;L+1;:FOR M=J TO JA
3120 PRINT USING G2$;R(L,M);:NEXT M:PRINT:NEXT L
3130 PRINT @ 960,"TYPE 'C' TO CONTINUE";
3140 Y$=INKEY$:IF Y$="C" THEN 3150 ELSE 3140
3150 NEXT J: NEXT I
3160 RETURN
4000 ' COMPUTE MEANS, SIGMAS, CORRELATIONS
4010 ' N=NUMBER OF VARIABLES.  N=N-1 IF IB (STARTING
```


 Circle 235 on inquiry card.

Listing 1a continued:

```
4020 ' ELEMENT IN ARRAYS=0, ELSE N=N.
4030 GOSUB 4120
4040 GOSUB 4210
4050 T=NS:FOR I=IB TO N:A(I)=A(I)/T
4060 S(I)=SQR(R(I,I)/T-A(I)[2):NEXT I
4070 FOR I=IB TO N:FOR J=I TO N:IF S(I)*S(J)=0.0 THEN 4090
4080 R(J,I)=(R(I,J)/T-A(I)*A(J))/(S(I)*S(J))
4090 R(I,J)=R(J,I):NEXT J:R(I,I)=1.0:NEXT I
4100 IF Y3$="Y" THEN GOSUB 4480
4110 RETURN
4120 ' SETUP PARAMETERS FOR CORL
4130 CLS:INPUT "ENTER ANALYSIS NAME";TL$
4140 INPUT "ARE THE DATA FROM TAPE";Y1$
4150 INPUT "DO YOU WISH TO SAVE THE DATA ON TAPE";Y2$
4160 INPUT "DO YOU WISH TO SAVE THE MATRIX";Y3$
4170 Y1$=LEFT$(Y1$,1):Y2$=LEFT$(Y2$,1):Y3$=LEFT$(Y3$,1)
4180 IF Y1$+Y2$<>"YY" THEN RETURN
4190 PRINT"***ERROR***YOU CANNOT BOTH READ AND SAVE DATA TAPE"
4200 PRINT "RUN IS TERMINATED":END
4210 ' INPUT/OUTPUT SUBROUTINE FOR CORL
4220 CLS:NS=0:IF Y1$<>"Y" THEN 4230 ELSE 4240
4230 IF Y2$<>"Y" THEN 4290
4240 PRINT "PLACE DATA TAPE IN RECORDER"
4250 PRINT @ 960,"TYPE 'C' TO CONTINUE";
4260 Y$=INKEY$:IF Y$="C" THEN 4270 ELSE 4260
4270 IF Y1$="Y" THEN 4280 ELSE 4290
4280 CLS:PRINT "DATA ARE BEING ENTERED FROM TAPE":GOTO 4310
```

Listing 1a continued on page 434

Listing 1a continued:

```
4290 CLS:PRINT "ENTER DATA FOR EACH VARIABLE"
4300 PRINT "TYPE 'END' WHEN DATA ENTRY COMPLETED"
4310 IF Y1$="Y" THEN INPUT #-1,NV$
4320 IF Y2$="Y" THEN PRINT #-1,NV$
4330 NV=VAL(NV$):FOR I=IB TO N:A(I)=0.0
4340 FOR J=IB TO N:R(I,J)=0.0:NEXT J:NEXT I
4350 FOR I=IB TO N
4360 IF Y1$<>"Y" THEN PRINT "OBS";NS+1;"VAR";I+1;
4370 IF Y1$="Y" THEN INPUT #-1,S$ ELSE INPUT S$
4380 IF S$="END" THEN 4460 ELSE S(I)=VAL(S$):NEXT I
4390 IF Y2$<>"Y" THEN 4420
4400 FOR I=IB TO N:S$=STR$(S(I))
4410 PRINT #-1,S$:NEXT I
4420 FOR I=IB TO N:A(I)=A(I)+S(I)
4430 FOR J=I TO NV-1:R(I,J)=R(I,J)+S(I)*S(J):NEXT J:NEXT I
4440 NS=NS+1
4450 GOTO 4350
4460 IF Y2$="Y" THEN PRINT #-1,"END"
4470 RETURN
4480 ' MATRIX OUTPUT SUBROUTINE
4490 CMD"T":CLS:PRINT "PREPARE MATRIX TAPE AND RECORDER"
4500 PRINT @ 960,"TYPE 'C' TO CONTINUE";
4510 Y$=INKEY$:IF Y$="C" THEN 4520 ELSE 4510
4520 PRINT #-1,TL$:PRINT #-1,NV,NS
4530 FOR I=IB TO N: PRINT #-1,A(I),S(I):NEXT I
4540 FOR I=IB TO N: FOR J=I TO N:IF I=J THEN 4560
4550 PRINT #-1,R(I,J)
```

Listing 1a continued:

```
4560 NEXT J:NEXT I
4570 CMD"R":RETURN
```

(1b)

```
 RUN
CORRELATION MATRIX PROGRAM
BY THOMAS WM. MADRON
2132 SAVANNAH TRAIL
DENTON, TX 76201

ENTER TOTAL NUMBER OF VARIABLES TO BE CORRELATED? 3
ENTER ANALYSIS NAME? TEST DATA
ARE THE DATA FROM TAPE? N
DO YOU WISH TO SAVE THE DATA ON TAPE? Y
DO YOU WISH TO SAVE THE MATRIX? Y
PLACE DATA TAPE IN RECORDER
TYPE 'C' TO CONTINUEENTER DATA FOR EACH VARIABLE
TYPE 'END' WHEN DATA ENTRY COMPLETED
OBS 1 VAR 1 ? 19
OBS 1 VAR 2 ? 23
OBS 1 VAR 3 ? 182
OBS 2 VAR 1 ? 24
OBS 2 VAR 2 ? 28
OBS 2 VAR 3 ? 212
OBS 3 VAR 1 ? 21
OBS 3 VAR 2 ? 29
OBS 3 VAR 3 ? 180
```

Listing 1b continued on page 436

Listing 1b continued:

```
OBS 4 VAR 1 ? 28
OBS 4 VAR 2 ? 30
OBS 4 VAR 3 ? 225
OBS 5 VAR 1 ? 28
OBS 5 VAR 2 ? 28
OBS 5 VAR 3 ? 199
OBS 6 VAR 1 ? 30
OBS 6 VAR 2 ? 26
OBS 6 VAR 3 ? 207
OBS 7 VAR 1 ? 30
OBS 7 VAR 2 ? 26
OBS 7 VAR 3 ? 200
OBS 8 VAR 1 ? 26
OBS 8 VAR 2 ? 25
OBS 8 VAR 3 ? 212
OBS 9 VAR 1 ? 14
OBS 9 VAR 2 ? 29
OBS 9 VAR 3 ? 206
OBS 10 VAR 1 ? 30
OBS 10 VAR 2 ? 28
OBS 10 VAR 3 ? 224
OBS 11 VAR 1 ? 21
OBS 11 VAR 2 ? 28
OBS 11 VAR 3 ? 210
OBS 12 VAR 1 ? 30
OBS 12 VAR 2 ? 27
OBS 12 VAR 3 ? 212
OBS 13 VAR 1 ? 28
OBS 13 VAR 2 ? 25
OBS 13 VAR 3 ? 206
OBS 14 VAR 1 ? 30
OBS 14 VAR 2 ? 27
OBS 14 VAR 3 ? 216
OBS 15 VAR 1 ? 30
OBS 15 VAR 2 ? 29
OBS 15 VAR 3 ? 212
OBS 16 VAR 1 ? 30
OBS 16 VAR 2 ? 28
OBS 16 VAR 3 ? 208
OBS 17 VAR 1 ? END
PREPARE MATRIX TAPE AND RECORDER
TYPE 'C' TO CONTINUECORRELATION MATRIX
TEST DATA
VAR:      1      2      3
   1  1.00 -0.01  0.47
   2 -0.01  1.00  0.37
   3  0.47  0.37  1.00
TYPE 'C' TO CONTINUEDO YOU WANT THE CORRELATION MATRIX REPRINTED? Y
CORRELATION MATRIX
TEST DATA
VAR:      1      2      3
   1  1.00 -0.01  0.47
   2 -0.01  1.00  0.37
   3  0.47  0.37  1.00
TYPE 'C' TO CONTINUEREADY
>
```

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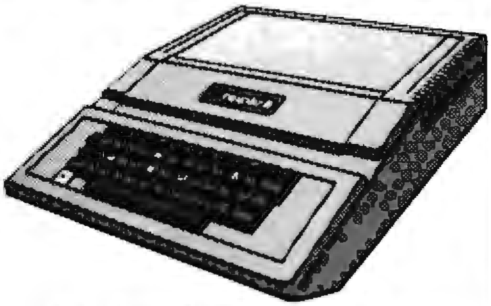
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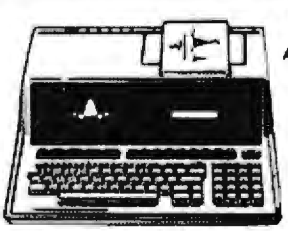
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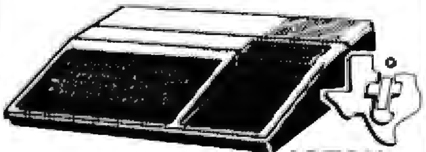
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Listing 2: *The regression calculating program (2a) and a test run (2b) written for the TRS-80 Model I Level II.*

(2a)

```
1000 ' MULTIPLE REGRESSION PROGRAM
1010 CLEAR:DEFINT I-N
1020 ' IF THE ZEROTH ELEMENT OF THE ARRAYS ARE USED, THEN
1030 ' IB MUST = ZERO, ELSE IB=1.  ND=THE MAXIMUM DIMENSION
1040 ' FOR EACH ARRAY (MAX VARIABLES).
1050 IB=0:ND=15
1060 DIM RY(ND,IB),R(ND,ND),X(ND,ND),A(ND),S(ND),B(ND,IB)
1070 DIM IX(ND),BE(ND)
1080 CLS:PRINT "MULTIPLE LINEAR REGRESSION PROGRAM"
1090 PRINT "BY THOMAS WM. MADRON (1979)"
1100 PRINT "2132 SAVANNAH TRAIL"
1110 PRINT "DENTON, TX 76201"
1120 FOR I=0 TO 800:NEXT I
1130 GOSUB 4000 :N=NV-(1-IB):NR=N:NC=N:GOSUB 3000
1140 CLS:INPUT "DO YOU WANT THE CORRELATION MATRIX REPRINTED";Y$
1150 IF LEFT$(Y$,1)="Y" THEN GOSUB 3000
1160 CLS:INPUT "VARIABLE NUMBER OF DEPENDENT VAR. FOR THIS RUN";IY
1170 IY=IY-(1-IB)
1180 INPUT"NUMBER OF INDEPENDENT VARIABLES IN THIS RUN";NI
1190 IF NI+1>NV THEN PRINT "*** TOO MANY VARIABLES ***":
        GOTO 1160
1200 PRINT "ENTER VARIABLE NUMBERS FOR INDEPENDENT VARIABLES"
1210 N=NI-(1-IB)
1220 FOR I=IB TO N:INPUT IM:IX(I)=IM-(1-IB):NEXT I
```


Circle 269 on inquiry card.

Listing 2a continued:

```
1230 N=NI-(1-IB)
1240 FOR I=IB TO N:K=IX(I):FOR J=I TO N
1250 L=IX(J):X(I,J)=R(K,L):X(J,I)=X(I,J)
1260 NEXT J:X(I,I)=1.0:NEXT I
1270 FOR I=IB TO N:J=IX(I):RY(I,IB)=R(IY,J):NEXT I
1280 GOSUB 6000 :N1=N:N2=IB:N3=N:GOSUB 2000
1290 A0=A(IY):R3=0
1300 FOR I=IB TO N:J=IX(I):BE(I)=B(I,IB)*(S(IY)/S(J))
1310 A0=A0-BE(I)*A(J):R3=R3+B(I,IB)*RY(I,IB):NEXT I:R4=SQR(R3)
1320 F1$="VAR      MEANS     SIGMAS   ZERO-R     BETA      B    R2-X(I)"
1330 F2$="###  ######.##  ######.##  ##.####  ##.####  ####.##  ##.####"
1340 FOR I=IB TO N STEP 10:J=I+9
1350 IF J>N THEN J=N
1360 CLS:PRINT TL$
1370 PRINT F1$
1380 FOR K=I TO J:L=IX(K)
1390 R5=R3-((B(K,IB)/SQR(X(K,K))))[2
1400 PRINTUSING F2$;IX(K)+1,A(L),S(L),RY(K,IB),B(K,IB),BE(K),R5
1410 NEXT K:PRINT @ 960,"TYPE 'C' TO CONTINUE";
1420 Y$=INKEY$:IF Y$="C" THEN 1430 ELSE 1420
1430 NEXT I
1440 CLS:PRINT TL$:PRINT "INTERCEPT=";A0
1450 PRINT "MULTIPLE R=";R4;"R-SQUARED=";R3
1460 D1=NI:D2=NS-(NI)-1:F1=(R3*D2)/((1-R3)*D1):GOSUB 5000
1470 PRINT "FOR DF1=";D1;"AND DF2=";D2;"F=";F1;"P=";P
1480 PRINT "NUMBER OF OBSERVATIONS=";NS
```

Listing 2a continued on page 440

Listing 2a continued:

```
1490 PRINT @ 960,"TYPE 'C' TO CONTINUE";
1500 Y$=INKEY$:IF Y$="C" THEN 1510 ELSE 1500
1510 CLS:INPUT "DO YOU WANT ANOTHER RUN";Y5$
1520 IF LEFT$(Y5$,1)="Y" THEN 1530 ELSE CLS:END
1530 RUN
2000 ' MATRIX MULTIPLICATION
2010 ' N1=NUMBER OF ROWS IN B AND X.  N2=NUMBER OF
2020 ' OF COLUMNS IN B AND RY.  N3=NUMBER OF COLUMNS
2030 ' IN X AND NUMBER OF ROWS IN RY.  SUBTRACT 1 FROM
2040 ' FROM EACH IF IB=0.
2050 FOR I=IB TO N1
2060    FOR J=IB TO N2
2070    B(I,J)=0
2080            FOR K=IB TO N3
2090            B(I,J)=B(I,J)+X(I,K)*RY(K,J)
2100            NEXT K
2110    NEXT J
2120 NEXT I:RETURN
3000 ' SUBROUTINE TO PRINT A MATRIX
3010 ' NR=NUMBER OF ROWS.  NC=NUMBER OF COLUMNS.  IF
3020 ' IB=0 THEN NR=NR-1 AND NC=NC-1.  IB=STARTING
3030 ' POINT FOR ARRAYS.
3040 FOR I=IB TO NR STEP 10:IA=I+9:IF IA>=NR THEN IA=NR
3050 FOR J=IB TO NC STEP 9:JA=J+8:IF JA>=NC THEN JA=NC
3060 CLS:PRINT "CORRELATION MATRIX":PRINT TL$
3070 F1$="VAR:":G1$="  ####":F2$="####":G2$=" ##.##"
3080 PRINT F1$;
```

Listing 2a continued:

```
3090 FOR L=J TO JA:PRINT USING G1$;L+1;:NEXT L:PRINT
3100 FOR L=I TO IA
3110 PRINT USING F2$;L+1;:FOR M=J TO JA
3120 PRINT USING G2$;R(L,M);:NEXT M:PRINT:NEXT L
3130 PRINT @ 960,"TYPE 'C' TO CONTINUE";
3140 Y$=INKEY$:IF Y$="C" THEN 3150 ELSE 3140
3150 NEXT J: NEXT I
3160 RETURN
4000 ' MATRIX INPUT FROM TAPE ROUTINE
4010 CMD"T":CLS:PRINT "PREPARE MATRIX TAPE AND RECORDER"
4020 PRINT @ 960,"TYPE 'C' TO CONTINUE";
4030 Y$=INKEY$:IF Y$="C" THEN 4040 ELSE 4030
4040 INPUT #-1,TL$:INPUT #-1,NV,NS
4050 N=NV-(1-IB)
4060 FOR I=IB TO N:INPUT #-1,A(I),S(I):NEXT I
4070 FOR I=IB TO N:FOR J=I TO N:IF I=J THEN 4090
4080 INPUT #-1,R(I,J)
4090 NEXT J:NEXT I
4100 FOR I=IB TO N:FOR J=I TO N:IF I=J THEN R(I,J)=1:GOTO 4110
      ELSE R(J,I)=R(I,J)
4110 NEXT J:NEXT I
4120 CMD"R"*RETURN
5000 ' PROBABILITY OF OCCURENCE OF F,T,Z,CHI-SQ
5002 ' ADAPTED FROM DONALD J. VELDMAN, FORTRAN PROGRAMMING
5004 ' FOR THE BEHAVIORAL SCIENCES (NEW YORK: HOLT, RINEHART
5006 ' AND WINSTON, 1967), PP. 129-131.
5010 ' D1, D2, F1  MUST BE SET BEFORE CALL
```

Listing 2a continued on page 442

Listing 2a continued:

```
5020 ' S IS RETURNED AS SIGNIFICANCE LEVEL
5030 P1 = 1.0
5040 IF D1 * D2 * F1 = 0.0 THEN 5260
5050 IF F1 < 1.0 THEN 5100
5060 A = D1
5070 B = D2
5080 F = F1
5090 GOTO 5130
5100 A = D2
5110 B = D1
5120 F = 1.0 / F1
5130 A1 = 2.0 / (9.0 * A)
5140 B1 = 2.0 / (9.0 * B)
5150 X = ((1.0 - B1) * F[.333333 - 1.0 + A1)
5160 Y = SQR(B1 * F[.666667 + A1)
5170 Z = ABS(X / Y)
5180 IF B < 4.0 THEN 5200
5190 GOTO 5210
5200 Z = Z * (1.0 + .08 * Z[4 / B[3)
5210 Z1 = (.115194+Z*(.000344+Z*.019527))
5220 P1= .5/(1.0+Z*(.196854+Z*Z1))[4
5230 IF F1 < 1.0 THEN 5250
5240 GOTO 5260
5250 P1 = 1.0 - P1
5260 P=P1
5270 RETURN
6000 ' MATRIX INVERSION USING EXCHANGE METHOD
```


Listing 2a continued:

```
6010 ' N, IB MUST BE SET PRIOR TO CALL
6020 IF N>ND THEN 6030 ELSE 6050
6030 PRINT "MATRIX SIZE IS LIMITED TO";ND
6040 PRINT "YOU HAVE A SIZE OF";N:END
6050 FOR K=IB TO N:D=-1/X(K,K)
6060 FOR J=IB TO N:IF J=K THEN 6080
6070 X(K,J)=X(K,J)*D
6080 NEXT J
6090 D=-D
6100 FOR I=IB TO N:IF I=K THEN 6160
6110 E=X(I,K)
6120 FOR J=IB TO N:IF J=K THEN 6140
6130 X(I,J)=X(I,J)+X(K,J)*E:GOTO 6150
6140 X(I,K)=X(I,K)*D
6150 NEXT J
6160 NEXT I
6170 X(K,K)=D:NEXT K:RETURN
```

(2b)

```
RUN
MULTIPLE LINEAR REGRESSION PROGRAM
BY THOMAS WM. MADRON (1979)
2132 SAVANNAH TRAIL
DENTON, TX 76201
PREPARE MATRIX TAPE AND RECORDER
TYPE 'C' TO CONTINUECORRELATION MATRIX
```

Listing 2b continued on page 444

Listing 2b continued:

```
TEST DATA
VAR:       1       2       3
   1   1.00  -0.01   0.47
   2  -0.01   1.00   0.37
   3   0.47   0.37   1.00
TYPE 'C' TO CONTINUEDO YOU WANT THE CORRELATION MATRIX REPRINTED? N
VARIABLE NUMBER OF DEPENDENT VAR. FOR THIS RUN? 3
NUMBER OF INDEPENDENT VARIABLES IN THIS RUN? 2
ENTER VARIABLE NUMBERS FOR INDEPENDENT VARIABLES
? 1
? 2
TEST DATA
VAR        MEANS      SIGMAS    ZERO-R      BETA        B     R2-X(I)
  1        26.19        4.81    0.4743    0.4791      1.19    0.1354
  2        27.25        1.79    0.3679    0.3740      2.50    0.2250
TYPE 'C' TO CONTINUETEST DATA
INTERCEPT= 107.825
MULTIPLE R= .604004 R-SQUARED= .364821
FOR DF1= 2 AND DF2= 13 F= 3.73333 P= .0514039
NUMBER OF OBSERVATIONS= 16
TYPE 'C' TO CONTINUEDO YOU WANT ANOTHER RUN? N
READY
>
```

Correlation Program

Line Numbers	Routine
1000-1170	main program
3000-3160	matrix-printing subroutine
4000-4570	correlation-matrix subroutine
4120-4200	read correlation parameters
4210-4470	data-input routine
4480-4570	matrix-tape-output routine

Regression Program

Line Numbers	Routine
1000-1530	main program
2000-2120	matrix-multiplication subroutine
3000-3160	matrix-printing subroutine
4000-4120	matrix input from tape
5000-5270	probability-of-occurrence subroutine
6000-6170	matrix-inversion subroutine

Table 1: *Organization of the correlation and regression programs. The main difference between the two is in the subroutines that begin at line 4000. It is impossible to consolidate the two into a single program (see text for details).*

Text continued from page 431:

gram and a series of subroutines (easily noted in the listings).

Modifying the Programs

The correlation program and the regression program are similarly organized (see table 1), but the latter reads data exclusively from a tape file generated by the correlation program. If a consolidated program is preferred, the correlation subroutine in the correlation program can be substituted for the matrix-input-from-tape subroutine in the regression program. Both subroutines begin at line 4000 in their respective programs. A consolidated program takes only about 6 K bytes of memory.

Because the program is based on matrix algebra, several of the subroutines can be replaced with BASIC matrix functions. While Level II BASIC for the TRS-80 has no matrix functions, it is possible to obtain a software package (from Racet Computes of Orange, California) that provides those functions. And other BASICs, of course, may have the functions. For example, with the Racet functions, the matrix-inversion subroutine (lines 6000 through 6170) of the regression program could be changed to the following:

```
6000  ' MATRIX INVERSION
6010  I = &MINV(R,X,NV-1,
         D1,D2):  RETURN
```

Or in a DEC (Digital Equipment Corporation) BASIC system, it might appear as follows:

```
6000  ' MATRIX INVERSION
6010  MAT C = INV(R)
6020  RETURN
```

In both cases, some other (minor) changes would have to be made to the main program, but both techniques could be used. Built-in matrix functions, such as the example from DEC, do not typically use the zeroth row or column of arrays, thus wasting considerable memory. If these programs are implemented using such functions, however, the variable IB (line 1050) can simply be changed to 1, thus eliminating the use of the zeroth row and column throughout the program. The Racet functions use the zeroth row and column, and IB would be left unchanged. Bear in mind that these are only examples and that if the matrix functions are available, the program might be simplified in other ways as well.

Since arrays in Level II BASIC can be dynamically dimensioned, a variable (ND) is also set in line 1050 to the largest number of variables that might be contained with any given memory size. Even in a

16 K-byte machine, the dimensionality could be expanded beyond the default (ND = 15). Parameters for each problem are established conversationally in both programs, and parameters for regression can be found in lines 1130 through 1220. Questions requiring a yes or no answer can be answered with either "Y" or "YES" or "N" or "NO".

Data needed by the regression program includes the sequential number of the dependent variable in the run (a sequential number from 1 to the total number of variables correlated), the number of independent variables (any number from 1 to the total number of independent variables for the run), and the sequential variable numbers of NI, the number of independent variables. The program is structured so that at the end of a run, the user is asked if there will be another run (from some subset of the variables correlated). This capacity is especially useful when doing activities such as causal modeling.

All printing, whether of the correlation matrix or other elements of the analysis, is formatted to fit the display screen of the TRS-80 (16 lines by 64 characters). The display is stopped at various stages throughout the program and information is communicated to the user with the following BASIC statements:

```
xxxx  PRINT @ 960,"TYPE 'C' TO
      CONTINUE";
yyyy  Y$ = INKEY$: IF Y$ = "C"
      THEN zzzz ELSE yyyy
zzzz  next line
```

Many BASICs may not have the INKEY$ function that accepts input from the keyboard without waiting for the Enter or Return key to be pressed. To work properly, it must be placed in a loop, as illustrated. The PRINT @ 960 statement prints the message at position 960 (the 16th line of the display) on the screen.

Actual calculation of the statistics for the regression begins at line 1230. The correlation matrix R(I,J) is subset into X(I,J), which includes only the independent variables for the run (lines 1230 through 1260). Array X(I,J) is inverted to provide the information necessary to calculate the b^*s. The call to the matrix inversion routine is at line 1280 (GOSUB 6000). In lines 1290 through 1460, several statistics are calculated and displayed for each independent variable, including the mean, standard deviation, zero-order correlations with the dependent variable, b^*, b, and R^2 with the variable deleted. The last statistic is useful in evaluating the impact of a given independent variable on the total regression. Finally, the summary regression statistics are calculated and printed in lines 1440 through 1490, including the intercept a, R, R^2, F, degrees of freedom for F, and p (the probability of occurrence of F). The probability is calculated with a call to the probability subroutine (GOSUB 5000). The rationale for the computational algorithm is given in Veldman's book (reference 5, pages 129 through 131). The same subroutine can also be used

to calculate the probability of occurrence for *t* statistics, *z*, and chi-square (see reference 5). The program then tests for another run or terminates execution (lines 1510 through 1520).

Extensions and Modifications

If the computer being used is a Radio Shack TRS-80 Model I, the correlation and regression programs will run as presented here. If the program is being implemented on another computer, it is likely that most of the screen-formatting routines will have to be changed. As mentioned above, the regression program can be simplified by replacing the matrix subroutines with machine-language matrix functions (such as those from Racet) or with native functions (such as exist in DEC BASIC). The number of variables that can be used by the program can be increased or decreased by changing only the initialized value of ND in line 1050 of both programs. The number of variables depends on memory size, but even on a 16 K-byte machine the number could be increased significantly.

All I/O of original data is handled in the correlation-matrix subroutine with calls to internal subprograms. If a floppy-disk drive is available, a decided advantage can be gained by saving the data and matrix on disk rather than on tape. Because the matrix can be saved, it can be used for input not only to regression but also to other programs. One possible addition to regression might be to add a routine to allow input of the means, standard deviations, and correlation matrix from the keyboard so that published matrices might be analyzed. The original input data can also be saved on tape and could be used in the regression program to calculate predicted values of *Y* and residuals.

The keyboard data-entry routine (beginning at line 4210 of the correlation program) is rather primitive and includes no means for verifying the veracity of the data—such a check method might be a useful addition to the program. While there are techniques for calculating a multiple regression other than the one presented here, one of the primary strengths of this approach is that the regression is actually calculated from the correlation matrix. Consequently, it is possible to calculate correlations when some data is missing (different *N*s for different pairs of variables).

There are pitfalls when doing this, but unless there is a lot of missing data (especially on large samples), it is quite useful. The actual correlation routine could be modified to handle missing data, and perhaps some scheme for differentially weighting observations might be included to allow the user to modify various distributions. Again, some caution should be exercised when doing such modifications to the data. In any event, if such modifications are made, they need be made only in the correlation subroutine—the regression program need not be touched.

As a final note, the various subroutines provided in this program are sufficiently general so that they can be used in other programs designed by the reader. In fact, only the calling program is specific to the regression or correlation functions. It would save time to build a subroutine library that could have general applicability. Although Level II BASIC does not provide the means for merging all or part of programs from tape to existing programs in memory (Radio Shack Disk BASIC does have a merge function), several software vendors currently supply such utilities that will do the job nicely. ■

References

1. Adler, Alfred. "The Micro-Mathematician." *Interface Age*. October 1979, page 39. (Includes a discussion of matrix algebra.)
2. Adler, Alfred. "The Micro-Mathematician." *Interface Age*. November 1979, page 30. (Discusses matrix inversion.)
3. Kerlinger, Fred N and Elazer J Pedhazur. *Multiple Regression in Behavioral Research*. New York: Holt, Rinehart and Winston, 1973. (See especially chapters 3 and 4.)
4. Racet Computes. Infinite BASIC. (Matrix and string package for the TRS-80). 702 Palmdale, Orange, CA 92665.
5. Veldman, Donald. *FORTRAN Programming for the Behavioral Sciences*. New York: Holt, Rinehart and Winston, 1967.

Bits and Bytes in Pascal

And Other Binary Wonders

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There are no "secrets" in this article. I will simply show you some tricks that can be performed with UCSD Pascal. Like many programming tricks, these are of interest for two main reasons: to ease complicated system programming and to encourage fun programming.

All of the facts that I use can be found in the documentation available for UCSD Pascal (developed at the University of California at San Diego). However, these features have been documented very lightly up to now, with little or no explanation. Before I attempt to explain them I want to cover myself as follows: everything in this article has been tested with Apple II Pascal (both the original release and the current Version 1.1). Except as noted, I believe it should apply to other versions of UCSD Pascal—but I don't guarantee it.

Be warned: If you employ these tricks, you will abandon some of the safety features of the language. This could easily result in incomprehensible bugs in your program. Even if the program works correctly, you may run into trouble when you try to modify it. You should also be aware that tricks that work with your present system may not work with an updated version. Furthermore, the people who sold you your UCSD Pascal are under no obligation to support any features that they don't document themselves.

However, if you study these tricks you'll be able to do some things that are otherwise impossible. You'll also gain some insights into how the system works when it runs a Pascal program. You will find that your Pascal program can treat memory as a collection of bytes, which are in turn made up of bits; that data types are more changeable than they appear; that AND, OR, and NOT are more powerful than you thought; and that you can access specific machine locations in the same way you would with the PEEK and POKE keywords of BASIC.

Background

The original definition of Pascal is contained in the *Pascal User Manual and Report* by Kathleen Jensen and Niklaus Wirth. I call this original definition Classical Pascal, in order to distinguish it from UCSD Pascal. Classical Pascal was intended for use as a teaching language, and as such it embodies many features that support "good" programming practice. It even has features that *enforce* good practice.

Good practice, in programming or anything else, depends on what you're trying to achieve. For example, suppose you're developing a driver program for an exotic peripheral device. The question is, can you do the job conveniently and efficiently with normal good-practice programming in Classical Pascal? And the answer is, you could—but you'd prefer to circumvent the strictures of Classical Pascal. Perhaps you'd like to treat an integer value as an array of bits, or access a machine location by its physical address without using machine language.

A major assumption of Classical Pascal philosophy is *strong typing* (ie: any value represents data of one type only, and it cannot be directly interpreted as if it were of another type). Jensen and Wirth did provide a mechanism for defeating strong typing—the free-union record variant—but they didn't explain its use in the *Pascal User Manual and Report*. I will do so later in this article.

Another assumption of Classical Pascal is that there are only two boolean values, represented by the built-in constants TRUE and FALSE. But in UCSD Pascal, a boolean value can actually be any pattern of 16 bits and it is *interpreted* as either true or false. The boolean operators AND, OR, and NOT are usually assumed to do single operations on values of TRUE and FALSE; actually, however, they are *bitwise logical operators* with 16-bit operands. This per-

mits some uses of boolean values and operations that are normally not considered part of Pascal.

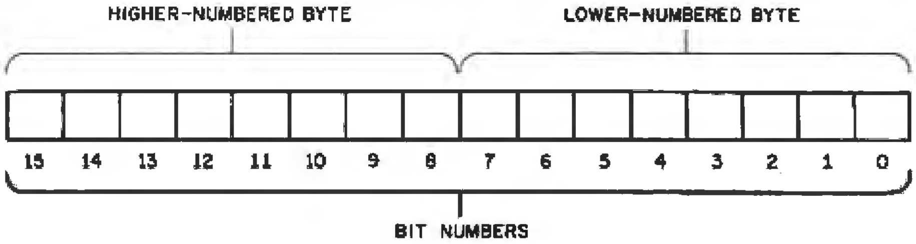


Figure 1: *Representation of a 16-bit word in UCSD Pascal. Every nonpacked scalar value is represented as two 8-bit bytes; least-significant bits are stored in the lower-numbered byte, while most-significant bits are stored in the higher-numbered byte.*

Representing Scalar Values

In order to understand and apply these special techniques, you need to know how some of the data types are represented internally. The following sections provide details on how data is represented in binary for each scalar data type. A later section deals with arrays. (By the way, when I say "scalar" I don't include the real-data type. Jensen and Wirth define the real type as a scalar type, but then they continually modify by saying "any scalar type except real." The fact is that real types are not very similar to other scalar types and I consider them a different category. If you're a purist, you can whisper "except real" each time the word "scalar" appears.)

The basic unit of storage in UCSD Pascal software is a 16-bit word that consists of two 8-bit bytes (on most microcomputers). The least-significant byte is at the lower of the two byte addresses. Figure 1 shows how to visualize a word; the least-significant bit is bit 0. Every nonpacked scalar value is represented in *one word*, as a 16-bit binary number.

Integers

An integer value is represented in one word as a binary number, with the least-significant bits in the low-numbered byte. Two's-complement notation is used to represent negative integers; thus, the most-significant bit of the binary number is a sign bit for the integer. If it is a 1, the integer value is negative and must be interpreted accordingly (see table 1).

Characters

A character is represented in one word by its ASCII (American Standard Code for Information Interchange) code. Since ASCII codes are in the range 0 through 255, they only require 1 byte; the character code is represented in the low-numbered byte of the word. (The most-significant byte contains 0s.)

Booleans

A boolean value is represented in

Integer Value	Stored Number Decimal	Hexadecimal	
0	0	0	
1	1	1	
.	.	.	
.	.	.	
.	.	.	
32766	32766	7FFE	
32767	32767	7FFF	$(2^{15}-1)$
−32768	32768	8000	(2^{15})
−32767	32769	8001	
.	.	.	
.	.	.	
.	.	.	
−2	65534	FFFE	
−1	65535	FFFF	$(2^{16}-1)$

Table 1: *Two's-complement notation. Both positive and negative integers are represented by using the most-significant bit as a sign bit. Negative integers are represented as binary numbers in the range 32768 to 65535.*

one word. The logical true or false value is represented by the least-significant bit of the least-significant byte. For most purposes, this is the only meaningful bit and all others are ignored—but read on.

User-Defined Scalars

When you declare a user-defined scalar type, each of its value identifiers is associated with an *ordinality* value; the first one declared has an ordinality of 0, the next has an ordinality of 1, and so forth. For example, the declaration:

```
VAR DAY: (MON, TUES, WED,
  THURS, FRI, SAT, SUN);
```

creates a variable DAY whose possible values (at the source program level) are MON through SUN. These are associated with the ordinalities 0 through 6; thus, MON corresponds to 0, TUES corresponds to 1, and SUN corresponds to 6. If DAY is assigned a particular value, such as the following:

```
DAY := WED
```

the value is represented in binary as the number 2, because WED corresponds to 2.

Implications

By combining this information on

representation of scalars with the following facts about the ORD and ODD functions, you can do some interesting things.

The ORD and ODD Functions

The familiar ORD function accepts a noninteger scalar value as its parameter, and returns an integer which is the ordinality of that value within its type. This is done in a strikingly simple way: ORD merely returns the very same value that was passed to it, and since ORD is, by definition, an integer function, the returned value is now interpreted as an integer. The method works because every nonpacked scalar value is represented in the same way: as a 16-bit binary number. The integer value of the binary number is the ordinality of the scalar value.

The ODD function accepts any integer as its parameter; it returns true if the integer is odd, and false if the integer is even. Notice that odd and even depend only on the last bit of an *integer* value (you will recall that true and false depend only on the last bit of a *boolean* value). ODD actually returns the same value that was passed to it; since ODD is, by definition, a boolean function, the returned value is now interpreted as a boolean value.

This implies that the binary form of any scalar value can be interpreted according to its original type, or as an integer, or as a boolean value. Accordingly:

- To interpret the binary value of any noninteger scalar S as an integer, use ORDS(S).
- To interpret the binary value of any integer N as a boolean, use ODD(N).
- To interpret the binary value of any noninteger scalar X as a boolean, use ODD(ORD(X)).

Incidentally, the SUCC and PRED functions work by simply incrementing or decrementing the binary value of a scalar (its ordinality) and returning the result as a scalar of the same type.

The program BITFIDDLER (listing 1) is a simple-minded application of these ideas. It allows you to see an integer value as a list of bit values, set a selected bit, and clear a selected bit. In order to do this, it makes use of the fact that AND, OR, and NOT are 16-bit operations. It sets up an array of 16 integer values, each of which has a 1 in one particular bit and 0s in all other bits (the values are powers of 2).

Each of these power-of-2 values can be used in the TSTBIT function to test the corresponding bit of an integer via the AND operation. The result of the AND is a nonzero integer if the tested bit is a 1, and a 0 integer if the bit is a 0. The SETBIT procedure sets a bit by using the OR operation, and the CLEARBIT procedure clears a bit by using AND NOT.

To make these operations possible, the integer values must first be converted to type boolean by the ODD function. Then the boolean operation (AND, OR, or AND NOT) is per-

Circle 273 on inquiry card.

Listing 1: The BITFIDDLER program uses the ODD and ORD functions to manipulate data types. In the TSTBIT function and the SETBIT and CLEARBIT procedures, ODD is used to convert integer values into type boolean so that a bitwise boolean operation can be performed. (ORD then converts the result back to type integer.)

```
    PROGRAM BITFIDDLER;
(*This program takes an integer value from the keyboard and
  displays its value as a list of 16 bit values.  Then it
  sets a specified bit, displays the bit values again, clears
  a specified bit, and displays once more: *)

(*Declare a subrange type for indexing the bits of
  an integer value:*)
    TYPE BITNUMBER = Ø..15;

(*Declare an array of 16 integers -- one for each bit
  of an integer value:*)
    VAR BITVAL: ARRAY [BITNUMBER] OF INTEGER;
        I: BITNUMBER;
        INNUM, NUMBER: INTEGER;

(*A procedure to initialize the array so that each BITVAL[I] has a
  1 in bit I and Ø's in all other bits:*)
    PROCEDURE INITIALIZE;
      VAR I:BITNUMBER;
      BEGIN
        BITVAL[Ø] := 1;
        FOR I := 1 TO 15 DO BITVAL[I] := 2*BITVAL[I-1]
      END;

(*A function to return true if a particular bit of an integer value
  is a 1, or false if the bit is a Ø:*)
    FUNCTION TSTBIT (BITPOS: BITNUMBER; N: INTEGER): BOOLEAN;
      BEGIN
        TSTBIT := ORD(
                      ODD(N)
                      AND
                      ODD(BITVAL[BITPOS])
                     )
                  <> Ø
      END;

(*A procedure to analyze an integer value and report each bit:*)
    PROCEDURE ANALYZE(N: INTEGER);
      VAR I: BITNUMBER;
      BEGIN
        FOR I := Ø TO 15 DO BEGIN
          WRITE('Bit ', I, ' of ', N, ' is a ');
          IF TSTBIT(I, N) THEN WRITELN('1')
                          ELSE WRITELN('Ø')
        END;
      END;

(*A procedure to set (to 1) a particular bit of an integer variable:*)
    PROCEDURE SETBIT (BITPOS: BITNUMBER; VAR N: INTEGER);
      BEGIN
        N := ORD(
                 ODD(N)
                 OR
                 ODD(BITVAL[BITPOS])
                )
      END;

(*A procedure to clear (to Ø) a particular bit of an integer variable:*)
    PROCEDURE CLEARBIT (BITPOS: BITNUMBER; VAR N: INTEGER);
      BEGIN
        N := ORD(
                 ODD(N)
                 AND NOT
                 ODD(BITVAL[BITPOS])
                )
      END;
```

Listing 1 continued on page 453

formed. This gives a boolean result, which is converted back to type integer by the ORD function.

The boolean constants FALSE and TRUE are always represented as the 16-bit binary numbers 0 and 1, respectively. ORD(FALSE) is 0 and ORD(TRUE) is 1. In other words, FALSE has 0s in all 16 bits, while TRUE has a 1 in the least-significant bit and 0s in the other 15 bits.

As the BITFIDDLER program shows, there are other boolean values besides FALSE and TRUE—values that have 1s in other bit positions besides bit 0. I call these other values *strange* boolean values. For example, ODD(3) is a boolean true value but it is strange—it is represented by the 16-bit binary number for 3, not 1. It has 1s in both bit 0 and bit 1.

Use of Strange Booleans

In the BITFIDDLER program, we deliberately created strange boolean values, but you should be aware that a strange value can arise inadvertently. As shown above, ODD of any integer except 0 or 1 will give a strange value; the result is also strange when you complement a normal boolean value by using the NOT operator, because 1s appear in bits 1 through 15. In both of these cases, Classical Pascal says the result should be either TRUE or FALSE.

You might wonder how strange boolean values can work correctly in IF, WHILE, and REPEAT statements. They work because the system ignores all bits except the least-significant bit when it looks at the boolean value in an IF, WHILE, or REPEAT. Similarly, when two boolean values are compared, all bits except the least-significant bit are ignored.

But Classical Pascal allows other, less obvious uses of boolean values:

- A CASE statement can be controlled by a boolean value (with cases labeled TRUE and FALSE).
- An array index can be of type boolean.
- A FOR statement can have a boolean control variable that goes from one boolean value TO (or DOWNTO)

Listing 1 continued:

```
     BEGIN
       INITIALIZE;
       INNUM := 1;
       REPEAT
(*Get number from user:*)
          WRITE('Type an integer (-100 to quit): '); READLN(INNUM);
          NUMBER := INNUM;
(*Demonstrate testing the bits:*)
          ANALYZE(NUMBER);
(*Demonstrate setting a bit:*)
          WRITE('Set what bit in the value ', NUMBER, '? '); READLN(I);
          SETBIT(I, NUMBER);
          ANALYZE(NUMBER);
(*Demonstrate clearing a bit:*)
          WRITE('Clear what bit in the value ', NUMBER, '? '); READLN(I);
          CLEARBIT(I, NUMBER);
          ANALYZE(NUMBER)
       UNTIL INNUM = -100
     END.
```

another boolean value.

- A set of booleans whose possible members are the values TRUE and FALSE can be declared.

These uses may seem unusual, but they're normal in the sense that they are part of Classical Pascal. How do these uses work when a strange boolean value is involved?

You'll have to determine this answer for yourself, by experimentation. There are now so many versions of UCSD Pascal that I don't know how each of them deals with, say, a strange boolean value used as an array index. Some versions cannot handle strange boolean values in these situations. (The current Version 1.1 release of Apple II Pascal does handle strange boolean values correctly in all cases.)

Representation of Arrays

A nonpacked array of scalar values is represented simply as a sequence of words, with each word containing one scalar value as previously described.

When the array is packed, each value does not necessarily take up one word. The word is still the unit of storage, but each word can contain more than one value if it has enough bits. Consider the declaration:

VAR OCTAL: PACKED ARRAY[0..63] OF 0..7;

which creates an array OCTAL of 64 elements. Each element is an integer value in the range of 0 through 7, and requires 3 bits. Since a word contains 16 bits, 5 array elements can be packed into a word. The elements are packed so that the first element is in bits 0 through 2, the second is in bits 3 through 5, and so on, to the fifth ele-

ment in bits 12 through 14. Bit 15 is unused. The next element goes in bits 0 through 2 of the next word.

The following specific cases are of particular interest:

- A char value requires 8 bits. In a packed array of char, each word of storage contains two char values: the first is in bits 0 through 7, the second in bits 8 through 15.
- A value of the subrange type 0..255 also requires 8 bits and can be thought of as a "byte"-type value. Storage in a packed array of 0..255 is the same as for packed char values.
- A boolean value requires only one bit; in a packed array of boolean, each word contains 16 values. The first value is in bit 0; the last is in bit 15.

The above applies only as long as the variables remain packed. Whenever a value is unpacked from a packed variable, it is expanded to occupy a full word with 0s in any "unused" bits. This occurs whenever the value is used in an expression.

Free-Union Variants

An ordinary variant record has a tag-field value that is stored as part of the record. Your program can use the tag-field value to determine how the variant data is interpreted. This is useful when the variant data is of a specific type; the tag field serves as a safeguard against misinterpreting the variant data.

Here, however, we are interested in purposely interpreting the same data in more than one way. This can be accomplished with an ordinary variant record: simply ignore the tag field. If you use a *free-union* variant, you can eliminate the tag field altogether; this saves memory and also makes the maneuver a little more obvious.

A free-union variant looks like an ordinary variant, except that the tag-field identifier is omitted. A tag type is still required, as are case labels. For example:

```
VAR FOXY: RECORD CASE BOOLEAN OF
    FALSE: (INT: INTEGER);
    TRUE:  (BOOL: BOOLEAN)
  END;
```

Now FOXY.INT refers to a value of type integer, and FOXY.BOOL refers to a value of type boolean. Both refer to the same word of data. The labels FALSE and TRUE, corresponding to the tag type BOOLEAN, are chosen as a matter of convenience; you can use any type that has enough possible values to use as case labels. In the BINARY program shown in listing 2, the type THREEWAY is declared solely for use as a tag type for a free union that has three cases.

In the BITFIDDLER program, we used the INITIALIZE procedure to set up an array of integers, each integer having a 1 in one bit, and 0s in all other bits. This was accomplished by making the value of each integer a power of two. In the TSTBIT function and the SETBIT and CLEARBIT procedures, we used ODD to convert one of these integer values to a boolean value with a 1 in a particular bit.

In the BINARY program we use a

free union as a more powerful means of accessing individual bits of a boolean value—and more. This is a three-way free union that allows the same word of data to be treated as an integer, a boolean value, or an array of 16 boolean values.

Multidimensional Arrays

When you know how to access data in memory in this fashion, the representation of data values becomes more interesting. Consider multidimensional arrays.

When an array has more than one index, the last index varies most rapidly and the first index varies least rapidly. For example, in a two-dimensional array the second index can be thought of as a "column" index that steps along a row, and the first index can be thought of as a "row" index that steps from one row to the next. The elements in a row are contiguous in memory. Another way to think of this is that the declaration:

```
VAR TABLE: ARRAY[0..9, 0..4]
    OF INTEGER;
```

is exactly equivalent to:

```
VAR TABLE: ARRAY[0..9] OF ARRAY[0..4]
    OF INTEGER;
```

The ARRAY[0..4] OF INTEGER is a one-dimensional array, so its elements are contiguous. The ARRAY[0..9] OF ... is also a one-dimensional array whose elements are arrays.

Beware of multidimensional packed arrays! Remember that for each dimension of the array, the unit of storage into which values are packed is the word, so each array that makes up the multidimensional array occupies an integral number of words, with possible unused bits. For example, you might declare an 8-by-8 packed array of boolean (1-bit) elements:

```
VAR X: PACKED ARRAY[0..7,0..7]
    OF BOOLEAN;
```

If you expect that X will be stored so that all 64 elements are contiguous bits within 8 contiguous bytes, you are wrong. The declaration is equivalent to:

```
VAR X: PACKED ARRAY[0..7] OF PACKED
    ARRAY[0..7] OF BOOLEAN;
```

Each row of X is a packed array[0..7] of boolean, and occupies one word: 16 bits, not 8. X contains eight of these words (16 bytes); the most-significant 8 bits of each word are unused.

Listing 2: *The BINARY program employs free union to access the individual bits of a word. The word can also be accessed as an integer or a boolean. The distinction is made in the field of the record VALUE: the BINOUT procedure references VALUE.BITS with a subscript to access a bit, while the main program references VALUE.INT to access the word as an integer, or VALUE.BOOL to access it as a boolean.*

```
     PROGRAM BINARY;
(*This program takes an integer value from the keyboard and
  displays its value as a 16-bit binary number by treating it as
  a packed array of 16 one-bit boolean values.  Then it treats
  the value as one 16-bit boolean value, complements it, and
  again displays the result as a 16-bit binary number: *)

     TYPE
(*A type to use as tag type in a 3-way free union: *)
          THREEWAY=(A,B,C);
(*An index type for 16-element arrays: *)
          BITINDEX=Ø..15;
(*An array type of 16 booleans, each one represented as a bit: *)
          BITARRAY=PACKED ARRAY[BITINDEX] OF BOOLEAN;
(*A free union record type, which can represent an integer,
  or a bit array, or a boolean; same 16 bits in all cases: *)
          THREETYPES=RECORD CASE THREEWAY OF
                              A: (INT:INTEGER);
                              B: (BITS:BITARRAY);
                              C: (BOOL:BOOLEAN)
                            END;

     VAR
(*A general index variable: *)
          I:INTEGER;
(*A variable of the free union type: *)
          VALUE:THREETYPES;

(*A procedure which takes a parameter of free union type,
  treats it as a bit array, and writes the 16 bits out
  as 1's and Ø's: *)
     PROCEDURE BINOUT(NUM:THREETYPES);
(*An index variable: *)
        VAR K:BITINDEX;

        BEGIN
(*Scan the 16 bits, most significant first: *)
         FOR K:=15 DOWNTO Ø DO
(*If the bit is "true," write a 1; if it's "false," write a Ø: *)
           IF NUM.BITS[K] THEN WRITE('1')
                          ELSE WRITE('Ø');
         WRITELN;
        END;

(*Main program: *)
     BEGIN
(*Prompt the user for a decimal integer: *)
        WRITE('Type Number: ');
(*Store it as an integer value: *)
        READLN(VALUE.INT);
(*Write it as a binary integer: *)
        BINOUT(VALUE);
(*Complement the value as a 16-bit boolean: *)
        VALUE.BOOL:=NOT VALUE.BOOL;
(*Write it as a binary integer: *)
        BINOUT(VALUE);
        WRITELN
     END.
```

The Byte-Oriented Procedures

There is yet another way around the strong typing of Pascal—the use of byte-oriented procedures. UCSD's documentation describes FILLCHAR, MOVELEFT, MOVERIGHT, SCAN, and SIZEOF as subroutines for working with packed arrays of characters. The documentation mentions that the source and destination parameters for these routines are not type-checked, and, in fact, you should really think of them as subroutines for working with *ranges of memory bytes*. If you have the declarations:

```
VAR BIT: PACKED ARRAY[0..15] OF
           BOOLEAN;
    BOOL: BOOLEAN;
```

then you can transfer the value of BOOL into the bit array BIT by means of the following statement:

```
MOVELEFT (BOOL, BIT, 2)
```

which moves 2 contiguous bytes (one word) without checking data type.

PEEK and POKE

When you're writing in Pascal, there are very few situations where PEEKs and POKEs are of any use. The reason for this is that you don't know how the system is using memory. When you access memory using a physical address, you can easily blunder into an area used by the system.

Each version of UCSD Pascal generally contains its own built-in, high-level constructs for the situations where particular locations must be accessed. For example, the loudspeaker on an Apple II is activated by accessing a particular location, but Apple II Pascal provides a procedure called NOTE that lets you generate tones on the speaker without knowing the special location.

Suppose, however, that you have a peripheral device that wasn't anticipated by the designers of your UCSD Pascal, and it needs to be controlled by accessing a particular location. In BASIC, you would do this with PEEKs or POKEs; to get the same effect in Pascal, you must create Pascal PEEKs and POKEs.

There are two tricks in PEEKing and POKEing with Pascal. The first is to declare a variable type that corresponds to one physical memory byte. A byte is 8 bits, and can hold a value in the range 0 through 255. But if you declare:

```
TYPE BYTE = 0..255;
```

it won't work correctly. The problem lies in the fundamental rule that every nonpacked scalar is represented in memory as a word (16 bits). A variable of type BYTE will occupy 2 bytes, with 0 in the higher-numbered byte. To avoid this situation our "memory byte" type has to be *packed*:

```
TYPE BYTE = 0..255;
     MEMBYTE = PACKED ARRAY [0..0]
     OF BYTE;
```

Now a variable of type MEMBYTE is an 8-bit value that occupies just 1 memory byte.

The second trick is that a pointer variable is represented as if it were a scalar variable: it is a 16-bit binary number, and its numeric value is a physical address. Now we can declare a two-way free-union record type as

Listing 3: *PEEKing and POKEing. As shown in figure 3a, a two-way free-union record type can represent either a pointer value or an integer value. A direct reference to a physical location can be performed with the functions shown in figure 3b.*

(3a)

```
TYPE BYTE = 0..255;
     MEMBYTE = PACKED ARRAY [0..0] OF BYTE;
     LOCATION = RECORD CASE BOOLEAN OF
                   TRUE:  (ADDR: INTEGER);
                   FALSE: (PTR: ^MEMBYTE)
                END;
```

(3b)

```
PROCEDURE POKE (ADDRESS:INTEGER; VALUE:BYTE);
  VAR LOC: LOCATION;
  BEGIN
    LOC.ADDR := ADDRESS;
    LOC.PTR^[0] := VALUE
  END;

FUNCTION PEEK (ADDRESS:INTEGER): BYTE;
  VAR LOC: LOCATION;
  BEGIN
    LOC.ADDR := ADDRESS;
    PEEK := LOC.PTR^[0]
  END;
```

shown in listing 3a.

If LOC is a variable of type LOCATION we can assign a physical address, such as 32766, by writing:

LOC.ADDR := 32766

At this point, LOC.PTR ↑ [0] is a direct reference to the contents of byte location 32766. We can now declare a POKE procedure and a PEEK function (see listing 3b).

As in BASIC, there is one wrinkle to using PEEK and POKE. Because of the two's-complement notation for negative integers, the largest possible positive integer value is 32767, or $2^{15}-1$. In order to represent a physical address greater than this, you must use a negative integer to get the desired binary number (see table 1).

Going Further

You now have enough information to make experiments that will tell you even more about the inside workings of your system, and you may even discover more useful programming tricks. Remember the warning, though: tricky programming may work once, but you can receive a nasty surprise when you change your program, switch systems, or try to use an updated version of UCSD Pascal. ■

Apple Analog-to-Digital Conversion in 27 Microseconds

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We began designing a computer-controlled data-acquisition system for the Franklin and Marshall College observatory, when suddenly we realized that we would have to build our own A/D (analog-to-digital) circuit board. Most commercially available A/D boards are designed for the S-100 bus or computer buses other than the Apple II. The only board we found specifically designed for the Apple was both expensive ($395) and very slow (400 milliseconds). At this time, various manufacturers are announcing new A/D boards for the Apple, but these, too, are expensive, and at least one of these has only 8-bit resolution. Our data system required 10-bit accuracy and high-speed performance. The circuit we designed to meet these requirements costs less than $100. (See table 1.)

Circuit Description

The Apple A/D circuit can be divided into four sections. The input section consists of two 741-type operational amplifiers and an AD582 sample/hold amplifier. The op amps accept a signal between 0 and 10 V and provide a zero offset adjustment. The AD582 device follows the input voltage until it receives a control signal indicating that an analog-to-digital conversion is to take place. It then samples the input voltage and holds its output to that voltage for the duration of the conversion. Thus, the AD582 provides a constant voltage (adjustable with gain control) for the conversion process, preventing a rapidly changing input signal from destroying the accuracy of the conversion. The heart of the circuit's second section is an AD571 analog-to-digital converter device, which performs the actual conversion of voltage levels to digital data. (Both the AD571 and the AD582 are manufactured by Analog Devices, POB 280, Norwood MA 02062.) Section three contains the three-state-output latch devices, a 74125 and a 74LS244. On command from the microprocessor, these connect the output of the AD571 converter to the system data bus. Finally, the fourth section contains a 74LS138 demultiplexer that decodes the address bus input, controlling the actual operation of the A/D circuit through a 7400 quad two-input NAND device and a 7404 hex-inverter package.

The 7400 NAND gates play a critical role in the operation of this circuit. Address signals appear on the Apple II system bus for less than 1 microsecond, but the AD571 converter requires a pulse no shorter than 2 microseconds to initiate a conversion. Expanding the pulse width of this control signal with a flip-flop constructed from a 7400 device satisfied this requirement.

Referring to figure 1, a conversion begins when the

1	Apple protoboard	$24.00
2	741 op amps	0.80
1	AD582 sample-and-hold amplifier	14.05
1	AD571 analog-to-digital converter	23.00
1	7404 hex inverter	0.25
1	7400 quad dual-input NAND gates	0.22
1	74LS138 demultiplexer	0.99
1	74LS125 tri-state latch	0.89
1	74LS244 tri-state latch	2.95
1	10 K 10-turn potentiometer	10.65
1	10 K 1-turn potentiometer	3.30
	Total	$81.10

Table 1: *List of components necessary to build the A/D converter shown in figure 1. The prices given by the author may not be representative of current component prices.*

processor writes a datum to hexadecimal memory location C0A0 (assuming the A/D circuit card is plugged into slot two of an Apple). This sends the card select line ($\overline{DS}$) into a low state, enabling the 74LS138 demultiplexer to decode the zero value present on the three least-significant lines of the address bus, A_0 to A_2. Output zero of the 74LS138 (the START line in figure 1) goes low, which, combined with the $R/\overline{W}$ (READ/$\overline{WRITE}$) line already in a low state from the processor write, sets the flip-flop and forces the $B+\overline{C}$ line high. This tells the AD571 to prepare for a conversion. When it is ready, the converter sends the $\overline{DR}$ line high, resetting the flip-flop, sending $B+\overline{C}$ low and initiating the conversion. Thus the addition of the flip-flop permits the AD571 to start a conversion only when it is ready, assuring that the sub-microsecond pulses on the address bus will start a conversion.

The $\overline{DR}$ line remains high while the AD582 chip is making a conversion—about 25 microseconds. When $\overline{DR}$ goes low, the conversion is complete and the data is ready. This $\overline{DR}$ line could be used to provide an interrupt, but we chose to bring it to the data bus through a three-state latch and allow the computer to test $\overline{DR}$ repeatedly until it goes low. Because the circuit operates so fast, machine-language programs test $\overline{DR}$ only twice before it goes low, and BASIC programs do not run fast enough to catch $\overline{DR}$ while it is still high. Thus, testing $\overline{DR}$ with a software loop wastes very little time.

Operation

When the A/D card is signaled to begin a conversion,

Number	Type	+5	GND	−12 V	+12 V
IC1	LM741			4	7
IC2	LM741			4	7
IC3	AD582			5	10
IC4	AD571	10		12	
IC5	7404	14	7		
IC6	7400	14	7		
IC7	74LS138	16	8		
IC8	74125	14	7		
IC9	74LS244	20	10		

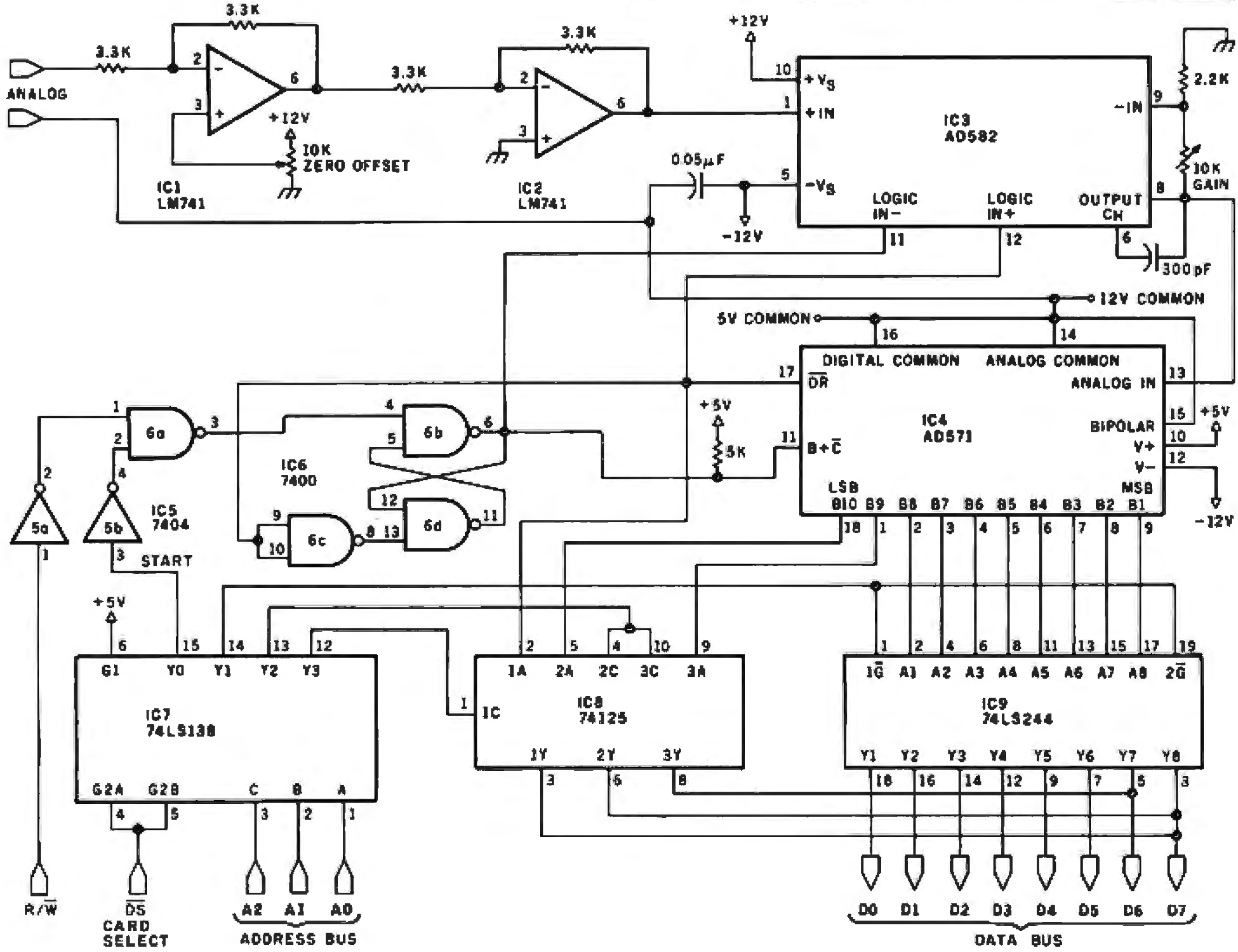


Figure 1: *Schematic of the A/D converter built on an Apple II plug-in prototyping card using ordinary soldering techniques. Two special components from Analog Devices comprise the heart of this fast and inexpensive circuit. This circuit can be easily adapted to other computer systems.*

the input circuit samples the analog voltage to be converted and holds it constant during the conversion. The A/D device makes the conversion, and once the 10 bits of data are ready, the board signals the computer by pulling $\overline{DR}$ low. The computer may then read the 8 MSBs (most-significant bits) in 1 byte and the 2 LSBs (least-significant bits) in another. If 8-bit resolution is sufficient, the 2 LSBs can be ignored.

Operation from a 6502 machine-language program is accomplished as follows. (Again, we assume the card is in slot 2.) The execution of STA $C0A0 (write the contents of the accumulator to hexadecimal location C0A0) begins a conversion. The computer then checks to see if the data is ready by LDA $C0A3 (read from C0A3). As soon as the eighth bit in this cell goes to 0, the data is ready and the computer can read the 8 MSBs with LDA $C0A1 and the 2 LSBs with a LDA $C0A2.

Command	6502 Machine Language	BASIC
Begin Conversion	STA $C0A0	POKE 49312,0
Get $\overline{DR}$	LDA $C0A3	PEEK (49315)*
8 MSBs	LDA $C0A1	PEEK (49313)
2 LSBs	LDA $C0A2	PEEK (49314)

**Unnecessary for BASIC programs*

Table 2: *Control and status commands for the A/D converter. Note that 2 bytes must be read to get 10-bit resolution. The memory locations specified and the machine-language and BASIC instructions are from the original installation on an Apple II.*



On our board, we found that the fifth bit of location C0A2 fluctuated between 0 and 1. When the computer is reading the contents of location C0A2, the 6 LSBs are undefined. The computer should recognize these as 0s, but that may not always be the case because of variations in the components. The solution is to mask the byte read from location C0A2 with an AND #$C0 (logical AND with the hexadecimal value C0). This ensures that the 6 low-order bits will be 0. Similarly, the contents of location C0A3 can be masked by an AND #$80 to be sure that only the eighth bit can be a 1.

The A/D board can also be operated from BASIC programs by using a POKE 49312,0 to begin the conversion and PEEK (49313) and PEEK (49314) to read the high- and low-order parts of the data. You must beware, however, of undefined bits in the low-order word. These can cause confusion and limit the board to 8-bit resolution when it is used from a BASIC program. These hexadecimal and BASIC commands are summarized in table 2.

The best arrangement for using the card from a BASIC program uses a short machine-language program to handle the actual conversion and masking. The program shown in listing 1 will assure that no undefined bits confuse the data. The program is relocatable and communicates with other programs via zero page locations FE and FF. The AND instructions mask off undefined bits.

If this subroutine is called from a BASIC program, the two words of data can be combined into a single number by:

X = PEEK (254)*4 + PEEK (255)/64

Division by 64 is necessary because the 2 LSBs occupy the two highest-order bits of the word in hexadecimal C0A2.

Speed

Analog Devices lists the speed of its AD571 chip as 25 µs, typical. Tests of our A/D board indicate that the time from the beginning of a conversion until the data is ready is about 27 µs. The time needed to read the 10 bits of data and store them in memory locations is about

Listing 1: *The 6502 machine-language routine called from BASIC that assures that no undefined bits will confuse the data read from the A/D circuit.*

```
8D A0 C0 Begin   STA  $C0A0   Start a conversion
AD A3 C0 Test    LDA  $C0A3   Get DR
29 80            AND  #$80    Mask off undefined bits
D0 F9            BNE  Test    Test DR
AD A1 C0         LDA  $C0A1   Get 8 bits of data
85 FE            STAZ $FE     Store in zero page
AD A2 C0         LDA  $C0A2   Get 2 bits of data
29 C0            AND  #$C0    Mask off undefined bits
85 FF            STAZ $FF     Store in zero page
60               RTS
```

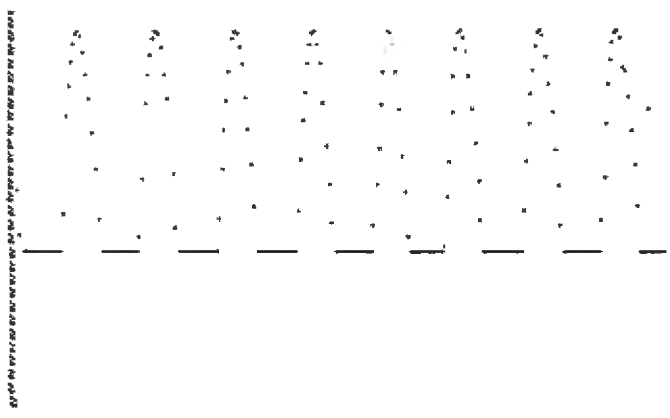



Figure 2: *A 1 kHz signal sampled at 8-bit resolution thirty-one times per cycle. Note that since the circuit described does not accept negative-input signals, the lower half of this signal has been clipped off.*

24 μs minimum, so the card can sample the input approximately every 50 μs. The overhead for data handling could be cut to 9 μs by using only the 8 MSBs.

Our operating system must be able to sample the input signal at a minimum of 1000 times per second at the direction of 1-millisecond interrupts from the clock. The speed of our A/D board gives us plenty of time to read the data, modify it as necessary, calculate the next empty address of memory (skipping over page 1 of the high-resolution display), and store the data. The system then waits for the next 1-millisecond interrupt before beginning the next conversion.

Figure 2 illustrates the speed of the card as used in our system. The input signal is a 1 kHz sine wave. The A/D converter accepts only positive voltages, so the negative portion of the sine wave is clipped. With the data-acquisition system free-running, independent of clock interrupts, and accepting only 8-bit resolution, the computer could sample the input signal thirty-one times per cycle.

Setup

This circuit has two controls that must be adjusted before the converter is used in any specific application. For example, the prototype (developed under a grant from the National Science Foundation) is used at an observatory to detect the light of a particular star as it disappears behind the moon. To compensate for excessive moonlight that can interfere with the measurements, the system is focused on a moonlit portion of the sky near the target star, and the *zero offset* control (see the schematic in figure 1) is adjusted until the converter gives a zero reading. The system is then focused on the target star and the *gain* control is adjusted for a full-scale reading (maximum output corresponds to maximum brightness). This ability to compensate for a variety of input conditions makes the A/D system adaptable to a wide assortment of applications. ■

PS—A FORTH-Like Threaded Language, Part 1

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[Editor's Note: *Alan Taylor of* Computerworld *once called the FORTH programming language "not so much a language itself as a hotbed for growing other languages." The PS language described in this article is a new language with its roots in the FORTH hotbed and the concept of subroutine-threaded code (see "Varieties of Threaded Code for Language Implementation" by Terry Ritter and Gregory Walker in the September and October 1980 issues of BYTE). This is an advanced theoretical article that draws heavily on a working knowledge of FORTH. For further information, see "What Is FORTH? A Tutorial Introduction" by John S James, and the other FORTH articles, in the August 1980 BYTE devoted to the language....*GW]

The main purpose of a programming system is to facilitate the user's communication with the computer.

I believe that operating systems or programming languages accepting something like conventional text are close to being ideal where the user-computer interface is concerned. All the other advantages or disadvantages of any particular system are "problem-oriented." In other words, what is convenient for one user might be unacceptable for another. Let us consider programming systems that are supposed to be useful for all potential users, beginning with the simplest system of this kind—assembly language.

There are many flaws with assemblers: assembly-language programs are not portable, they are difficult to write and debug, the user must have detailed knowledge of the computer hardware, and so on. However inconvenient it is, an assembly language is still a general-purpose programming system, much as the computer is a general-purpose data-processing device.

On the other hand, designers of high-level languages have to pay for obliterating low-level potential by supporting painful procedures of introducing assembler subroutines into a high-level program.

Thus, the problem with low-level languages is that they are not convenient to use; the problem with high-level languages is that they cannot be considered general-purpose programming systems because of their lack of low-level capabilities and their tendency to force programming structures that might not be optimal for the problem at hand.

The multilevel approach to programming has enriched FORTH with many interesting features.

FORTH is a good example of a multilevel system where this conflict is partially resolved. The multilevel approach to programming has enriched FORTH with many interesting features (see the article "What Is FORTH? A Tutorial Introduction" by John S James on page 100 of the August 1980 BYTE).

The principal idea of FORTH is to use a set of general-purpose low-level subroutines for encoding new ones, which can be further used for introducing more sophisticated programs. To implement this simple idea, FORTH provides the user with a set of tools, briefly described below.

FORTH maintains a dictionary where every subroutine is stored with its name and either an object code or a sequence of pointers to other subroutines in the dictionary. A dictionary entry is called a *word* and the address of a word in the dictionary is called a *word pointer*. In some FORTH systems, the sequence of the word pointers is preceded by a short piece of object code that executes (or "chains") the words being pointed to. A dictionary entry also contains the address of the previous word to facilitate searching for a word in the dictionary.

The low-level words in FORTH are stack operations like DUP (duplicate the number on the top of the stack), DROP , SWAP , + (add the two numbers on the stack), AND , OR , NOT , and @ (pronounced fetch and

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meaning replace an address on the top of the stack with its contents). All the stack operations are described more thoroughly in the "FORTH Glossary" (August 1980 BYTE, page 186).

The stack operations can be considered an expanded instruction set. Data can be introduced and accessed with the help of words like VARIABLE , CONSTANT , { ." } (pronounced dot-quote and meaning compile and type an ASCII string), &X (push ASCII code of X onto the parameter stack), etc. [*Remember that BYTE uses braces to delineate certain FORTH words and phrases; see the* PS Syntax *text box for more details....*GW]

It is easy to write programs in FORTH, but it is a pain in the neck to program in FORTH's assembler.

A programmer can define new words through the low-level ones or through the previously defined words, using such auxiliary tools as the control structures { IF...ELSE...ENDIF }, { BEGIN...AGAIN }, { BEGIN...UNTIL }, { DO...LOOP }, etc.

FORTH also has the capability of defining new words in the assembly language of the computer FORTH is running on. These words can be executed or used in high-level definitions as other words are used. Unfortunately, FORTH's assembler does not allow many of the facilities used while defining high-level words. For example, stack manipulations (DUP , DROP , SWAP , etc) are not supported, and no FORTH words can be mixed with the assembler code.

It is easy to write programs in FORTH itself, but it is a pain in the neck to program in FORTH's assembler. This is because you must abandon the capabilities of the high level and descend to an entirely new language—one that significantly differs from conventional assemblers, as well as from FORTH itself.

The reason why FORTH's assembler is not an organic part of FORTH is that these languages have different outputs: executable object code (for the FORTH assembler), and word pointers that must be chained to get executed (for FORTH itself). One way to resolve this conflict is a FORTH-like system that generates only object code without generating the word pointers. This two-part article describes the structure of a simple system of this kind, called PS (for Programming System).

Introduction to PS

Let us consider a programming system that is able to accept the following text:

ORIGIN *xxxx nn nnnn nn nnnn ...*
RUN *yyyy*

The words *nn* and *nnnn* represent 8- and 16-bit hexadecimal numbers. When a 16-bit number is compiled, the compilation address (also called *code pointer*) is incremented by 2. When an 8-bit number is compiled, the compilation address is incremented by 1.

ORIGIN is a special word that executes at compilation time. It takes the next word (*xxxx*) from the text, converts it to a 16-bit number, and sets the compilation address equal to this number.

RUN is another special word; it takes the next word (*yyyy*), converts it to a 16-bit number, and calls a subroutine at the address given by this number.

This primitive system has only one significant flaw: it is not very convenient to write programs directly in object code. But let us disregard the lack of convenience momentarily and think of an initial PS implementation. The compilation process operates as follows:

1. Read the next word from the text.
2. If it is a number, push it into the code and go to 1.
3. If it is a special word, execute it and go to 1.

The system will be more convenient with more special words defined. One such example is LABEL (which is used as { LABEL <name> }). It stores the word <name> together with the current compilation address into the dictionary.

We are considering a FORTH-like system that has a dictionary with all the necessary information about the special words. That is, now that the word LABEL is introduced, the PS dictionary contains three words: ORIGIN , RUN , and LABEL . The word LABEL allows the use of names instead of numbers in some situations.

Our system must be able to distinguish among several kinds of words: special words like ORIGIN or LABEL ; numbers; and labels, which are replaced with the number

PS Syntax

PS, like FORTH, uses punctuation in some of its words, which makes representing them in text a difficult problem. To decrease the chance of confusion while trying not to clutter text unnecessarily, we will sparingly use braces, {}, to isolate the character string within as a PS word or phrase. Braces will be used only under the following situations:

- *when the material being quoted is a phrase of PS words (eg: { 26 LOAD } or { 3 5 + })*
- *with the PS words { , } (comma), { : } (colon), { ; } (semicolon), { ! } (exclamation point), { ' } (single quote mark), { " } (double quote mark), { [} (left bracket), and {] } (right bracket)*
- *with any word using punctuation marks (eg: { ." })*

*All other PS words will be set apart by a space on either side of the word. So, in this article, braces will always signal a PS word or phrase. The braces are not part of the word or phrase, and PS words will never use braces within the body of a figure or listing....*GW

assigned to the label. We will use the phrase "value of the word" or the shorthand notation V to denote the current compilation address of the word, as stored in the dictionary with the word.

The new PS compilation process is:

1. Read the next word.
2. If it is a number, push it into the code and go to 1.
3. If it is a special word, execute it and go to 1.
4. If it is a label, push V into the code and go to 1.

The next step is to introduce undefined labels to allow forward references. If PS hits a name that is not in the dictionary, it assumes that the name's value will be defined later by LABEL . Meanwhile, PS makes a fake entry for this name with the value of the word, V, temporarily set to the current compilation address, also compiling 0000 into the code area instead of some real value (see figure 1a).

If PS hits an undefined label for the second time, it compiles the address of the fake entry (ie: the address of the previous reference to the undefined label) into the code area and sets V to the current code pointer decremented by 2, linking locations where the undefined label is used (see figure 1b).

When the LABEL statement is encountered, it must determine whether the word being defined has been used before. If it has, LABEL replaces the linked dummy pointers pointed to by the fake V with the value of the current code pointer. After this is done, V is also set to the value of the current code pointer, resolving the forward reference and turning the fake entry into the real one (see figure 1c).

It is more convenient to link and resolve forward references if the dictionary is separated from the code.

In general, PS links forward references to each other and to the value of the undefined word, with LABEL resolving forward references by storing the current code pointer in the locations linked by PS. If the word NEW is compiled at the address *cccc*, the resolved references appear as in figure 1c. The technique used here is essentially identical to that used by many one-pass assemblers and compilers.

It is more convenient to link and resolve forward references if the dictionary is separated from the code. This is because when PS hits a new word, a fake entry for this word is created before the space required to hold the code of the undefined word is known. This is very different from FORTH, which requires that every word be defined before it is used.

A More Sophisticated PS

This system has to distinguish between special words, numbers, defined labels, and undefined labels. Let us assume that the type of the word (T) is stored in the dictionary with the name and its value. The new version of PS is then as follows:

1. Read the next word.
2. If it is a number, push it into the code and go to 1.
3. If it is an old word, check its type:
   If T = special, execute and go to 1.
   If T = defined, push the value of the word (V) into the code area and go to 1.

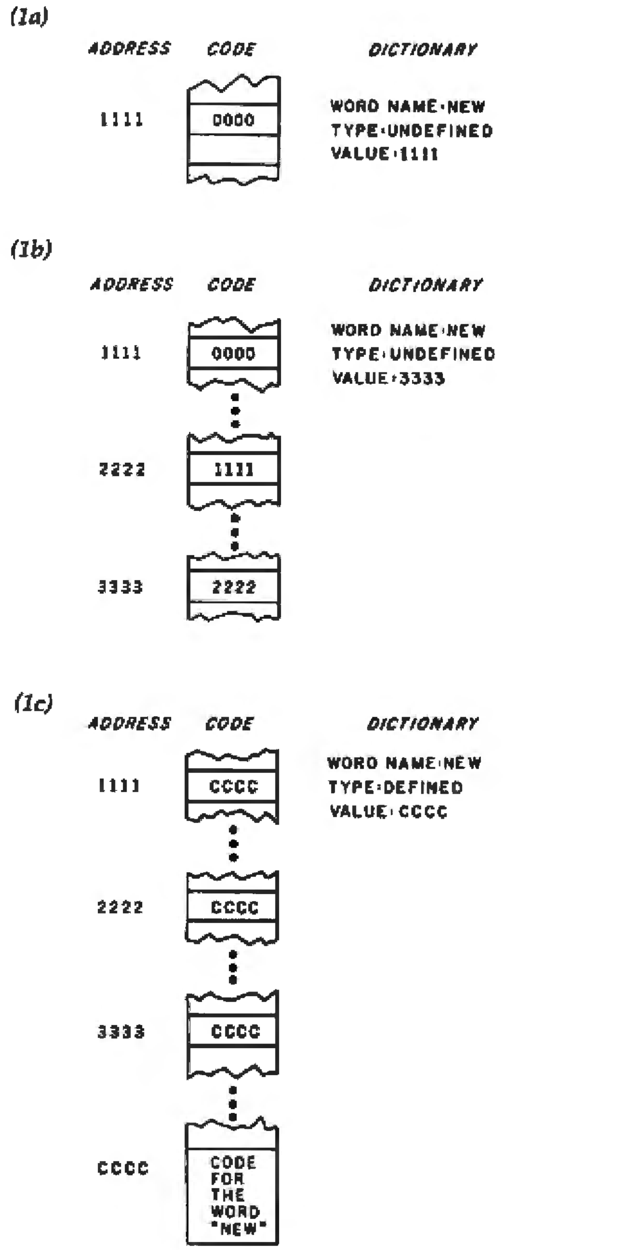


Figure 1: *Handling of forward references in PS. Figure 1a shows what happens when the word NEW is first encountered as an undefined word. Figure 1b shows several occurrences of the word NEW linked together. When the word NEW is finally defined (by use of the word LABEL), the address of NEW is put into its dictionary listing and into the previous references to it.*

If T = undefined, link the reference as described above and go to 1.

4. If it is a new word (ie: not encountered before): Make a new entry (that is, add this word to the dictionary), set the type to "undefined," set V to the code pointer, push 0000 into the code, and go to 1.

Let us introduce another special word "−> " (pronounced "jump to" and used as { −> <name> }). This word compiles a jump to the address corresponding to the word <name> .

Now that labels can be compiled by the special word −> , we can interpret the nonspecial words as names of subroutines that are to be compiled as JSR V, where JSR is a "jump to subroutine" instruction and V is the address of the subroutine. (We assume a 6502-based system here. You would substitute the appropriate machine-language instruction for systems based on other microprocessors.) So the principal idea of FORTH (ie: building programs from previously defined subroutines) is fully implemented now that the words LABEL and −> have been introduced.

Our system will be more useful if it can execute the compiled words. To switch PS from compilation to execute mode, we can introduce two special words: { [} (left bracket), which enables the execute mode, and {] } (right bracket), which enables the compile mode.

PS with the execute and compile modes looks as follows:

1. Read the next word.
2. If it is a number (this is discussed in more detail below).
3. If it is an old word in compile mode, check its type:
   If T = defined, compile JSR V and go to 1.
   If T = undefined, compile JSR (link), link it as described above, and go to 1.
   If T = special, execute it and go to 1.
4. If it is an old word in execute mode, check its type:
   If T = defined, execute it and go to 1.
   If T = undefined, print an error message, go to 1.
   If T = special, execute it and go to 1.
5. If it is a new word in compile mode:
   Make an entry, set the type to "undefined," compile JSR 0000, go to 1.
6. If it is a new word in execute mode, print an error message, go to 1.

An inquisitive reader now has at least two questions: what about arithmetic operations with labels, and what should happen to numbers?

The problem with numbers is that in one mode we want them to be compiled into the code; in another mode we want them to be pushed onto the parameter stack. The problem with arithmetic expressions is that we want addresses to be computed at compilation time.

The solution for both problems is to consider the compiled code as the parameter stack. That is, at run time we can push parameters into the free memory that follows

the compiled code. To keep track of the stack entries, we can increment (or decrement) the same code pointer used at compilation time. If the stack is used correctly, the code is not destroyed. Or we can check before every stack operation to make sure that the compiled code is never destroyed.

We will say that a number is *pushed onto the parameter stack* or *pushed into the code* or *compiled* whenever the number is stored in the location pointed to by the current code pointer. Then, in execute mode, numbers can be pushed into the code and added, multiplied, divided, etc, by the words + , − , / , and * . In compile mode, a number can be compiled with a preceding code that pushes the number onto the parameter stack at run time. This is done by the words PSHN (push number) and NUMBER, which will be discussed in part 2.

The use of the free space after the compiled code as a parameter stack adds much to the simplicity and flexibility of PS.

Low-Level Programming in PS

Let us assume that we have implemented PS with all the special words and stack operations described earlier. Let us also suppose that all the necessary subroutines are written in conventional assembly language, like that of the 6502 microprocessor, and are represented in the PS dictionary (ie: their names and addresses are stored in the PS dictionary with the assignment of the appropriate types).

Later, when speaking of the computer or the assembler, we mean the computer PS is running on and its assembler. We will also assume that the computer has a stack pointer for maintaining the computer stack and that the JSR instruction leaves the return address on the computer stack, just as it is done in the 6502. If there is no hardware stack, software can be written to simulate one.

Now, we will reexamine the simplest case—when PS is in execute mode with only numbers being compiled. If we want to compile an address or a 16-bit signed integer, we simply type in the number with either a leading zero (for positive numbers) or a minus sign (for negative numbers). Examples are 0*x*, 0*xx*, 0*xxx*, 0*xxxx*, −*x*, −*xx*, −*xxx*, and −*xxxx*. (Because PS accepts undefined words, it needs a way to distinguish numbers.) If we want to compile an instruction code or an 8-bit number, we can say # *xx*, where # is a special word that converts *xx* to an 8-bit number and pushes it into the code.

Our system will be more convenient if we introduce two more auxiliary words: CONST and BCONST. These are used as { CONST <name> *nnnn* } and { BCONST <name> # *nn* }, where *nnnn* and *nn* represent 16- and 8-bit numbers, respectively.

CONST (constant) makes a new entry in the PS dictionary for the <name> and compiles code that will push *nnnn* into the code at run time.

BCONST (byte constant) acts similarly, pushing an 8-bit number into the code at run time. The special word # is used with BCONST to emphasize the difference between CONST and BCONST. BCONST is used basically to compile 1 byte of object code. Thus, we can define the instruction set of the computer as a set of byte constants with whatever mnemonics we like. For example, on the 6502:

```
BCONST JSR # 20
BCONST JMP # 4C
BCONST RTS # 60
```

allow use of the mnemonics for the instructions "jump to subroutine," "jump via direct addressing," and "return from subroutine," instead of hexadecimal numbers 20, 4C, and 60. Also, naming the Boolean constants:

```
CONST TRUE 01
CONST FALSE 0
```

makes a program more readable.

To handle variables, the word VAR is used as { VAR <name> *nnnn* }. When VAR is executed, it creates a new entry for the word <name> and compiles object code that pushes the address of the memory location following this code onto the parameter stack at run time. The number *nnnn* is compiled by the text interpreter and is used to initialize the contents of the variable. One-byte variables can be defined as { VAR <name> # *nn* }.

A special word " (quote) is used as { " *aaaaaaa*" }, where *aaaaaaa* is a string of ASCII characters. The first quote compiles the following string preceded by its byte count. The second quote terminates the string. The space after the first quote is required so the text interpreter can identify quote as a word in its own right.

Strings can be defined in PS as follows: { VAR <name> " <some text>" }. When the word <name> is executed, the address of the string is pushed onto the parameter stack.

Arrays can be defined with the help of a special word called ARRAY, used as { ARRAY <name> *nnnn* }. When the word <name> executes, it pushes the address of the *nnnn* bytes, allocated for the array, onto the stack.

This completes part 1 of this article. In part 2, we will look at examples of low-level and high-level code in PS, and add a PS dictionary that includes some of the more technical details of the language.■

Acknowledgments

I want to thank the programmers and management of Friends Amis Inc for their help and support in carrying out this work, especially Jim Houha and Rick Greicar, who nearly rewrote the manuscript; Victor Eliashberg of VARIAN Associates, who helped me realize the significance of hardware-software relationships; Anya Kroth of the University of California at Santa Cruz for her sharp remarks and kind criticism; Dave Boulton, FORTH consultant and member of the editorial review board of the FORTH Interest Group, and Bill Wilkinson of Optimized Systems Software, who made this work more understandable. Samuel Feldman of Hewlett-Packard made this work more understandable for the author himself.

Recursive Procedures for the 6502 Microprocessor

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In recursive applications, the limited stack size of MOS Technology's 6502 8-bit microprocessor is a drawback. Due to the 6502's stack being restricted to one page (256 bytes starting at location 256, or page one of memory), subroutine calls are limited to a maximum of 128 levels. If the stack is used for temporary storage (or the recursive procedure calls other subroutines), then the depth of recursion possible is even less. Conversely, the Motorola 6800 microprocessor has a 16-bit stack pointer and the ability to locate the stack anywhere in memory.

Recently, I was confronted with this restriction during a conversion of S Tucker Taft's M6800 LISP interpreter to the 6502. (See reference 1.)

The stack-management routines in this "System Note" are based upon the 6800 routines in Mr Taft's article. The major difference is that the 6800 can relocate its stack rapidly via the TXS instruction, while the 6502 must perform a slower 256-byte move of the stack page to main memory.

The technique for carrying out 6502 recursive procedures requires the procedure to detect two conditions —the overflow of the stack and the underflow of the stack. To detect overflow, each call to the recursive procedure must be accompanied by a check of the stack pointer. If the recursive procedure requires a certain number of bytes of stack storage per call (STKMIN), then a call to the procedure when the stack pointer is within STKMIN bytes of the stack top results in a stack overflow. At this point, code is executed to move the current stack to main memory, pointers are saved to point to the

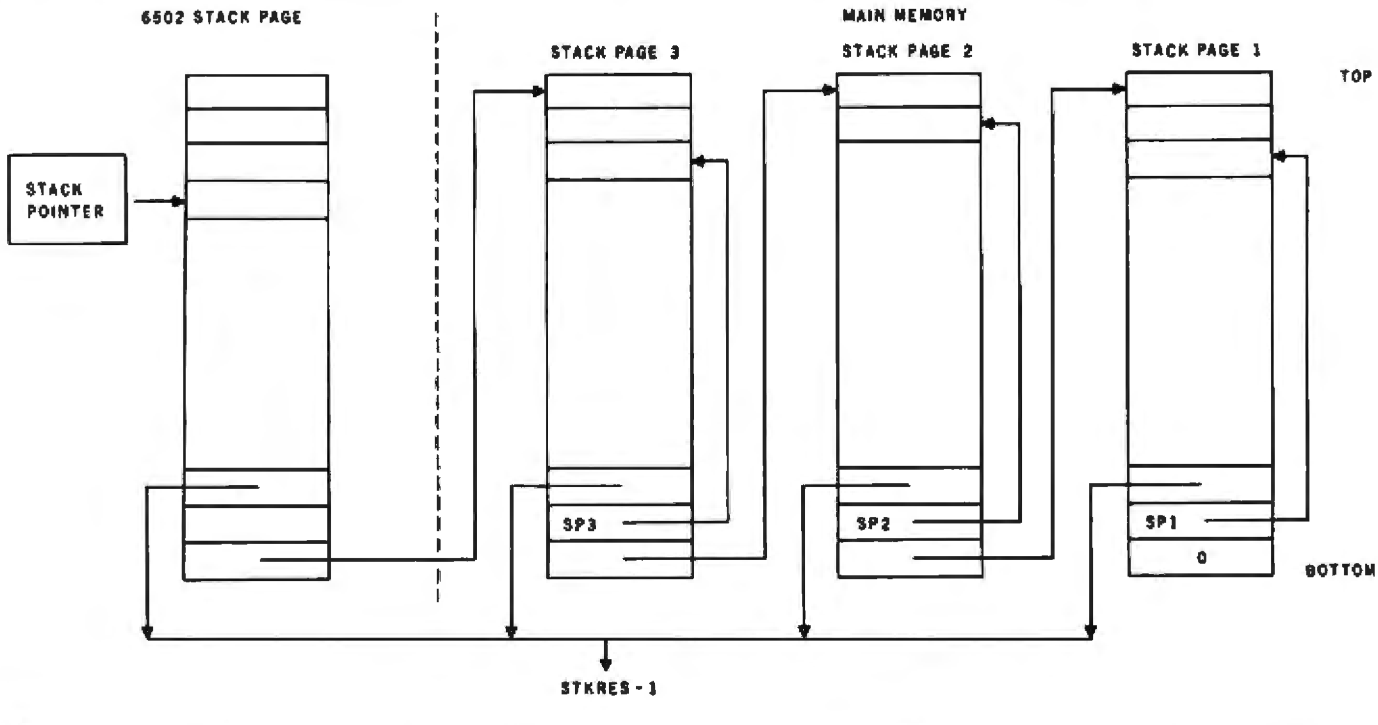


Figure 1: *Typical stack configuration during execution of a recursive procedure that uses the stack-management routines. When the normal 256-byte stack page (page one of the 6502 memory space) is full, the contents are moved to another part of memory, freeing an additional 256 bytes of stack space. If the stack pointer returns to the bottom of the current stack page, the stack-restore routine (STKRES) moves the previous stack page (if any) back from main memory to page one, where it is treated as the current stack. The value of the stack pointer at the time that page was moved to main memory (stored as SP1, SP2, etc) is also restored.*

area where the stack was moved, and the stack pointer is reinitialized to the bottom of page one.

Detection of a stack underflow normally occurs in only one instance—when the recursive procedure is returning to a level with a return address located in the portion of the stack that was moved to main memory. It is the responsibility of the underflow-detection routine to restore the stack from main memory. One way to detect the underflow condition is to check the stack pointer prior to every return from the recursive procedure, and if an underflow is detected, branch to a stack-restoring routine. This method is slow, tedious to code, and wasteful of precious memory.

Fortunately, there's a more elegant way to detect underflow. This is done by initializing the bytes at the bottom of the 6502 stack to point to a stack-restore routine. Thus, a return executed at the moment of underflow actually returns to the stack-restore routine, whose function is to restore the stack to the state prior to its move to main memory. This state can be represented by the value of the stack pointer at the moment it was moved to main memory and a pointer to the previously moved stack page. Figure 1 shows the memory configuration at a typical moment of execution.

Note that the implementation presented here assumes a memory-management scheme in which the stack pages in main memory are allocated from the low end of memory in increasing order, while all other data is allocated starting at the high end of memory in decreasing order. The pointers to these boundaries (figure 2) are stored at sym-

Listing 1: *Assembly-language stack-management routines for recursive 6502 procedures: STKINIT initializes the special stack; STKCHK checks for stack overflow; STKRES, executed at stack underflow, restores the previous stack to page one of the 6502 memory.*

```
:LIST

1000 *//////////////////////////////////
1010 *///                             ///
1020 *///    STACK MANAGEMENT         ///
1030 *///    PACKAGE FOR RECURSIVE    ///
1040 *///    6502 PROCEDURES.         ///
1050 *///                             ///
1060 *///    BY P.W. DENNIS           ///
1070 *///                             ///
1080 *///    SYMBOLIC LABELS          ///
1090 *///                             ///
1100 *///    (TOP) := POINTER TO      ///
1110 *///             DATA AT HIMEM   ///
1120 *///    (NEXT):= POINTER TO      ///
1130 *///             PREV STACK      ///
1140 *///             PAGE.           ///
1150 *///    LOMEM := INITIAL LOC.    ///
1160 *///             FOR 1 ST        ///
1170 *///             STACK MOVE.     ///
1180 *///    MEMFUL:= MEMORY FULL     ///
1190 *///             ERROR EXIT      ///
1200 *///    STKMIN:= STACK SPACE     ///
1210 *///             REQUIRED BY     ///
1220 *///             THE RECURSIVE   ///
1230 *///             PROCEDURE       ///
1240 *///                             ///
1250 *//////////////////////////////////
1260 *
1270 *
1280 *//////////////////////////////////
1290 *///                             ///
1300 *///    STACK INITIALIZATION     ///
1310 *///                             ///
1320 *///    PLACE IN LINE AS FIRST   ///
1330 *///    INSTRUCTIONS OF         ///
1340 *///    PROGRAM                  ///
1350 *///                             ///
1360 *//////////////////////////////////
1370 *
1380        LDX #LOMEM   ; INIT POINTER
1390        STX NEXT     ; TO LOW END
1400        LDX /LOMEM   ; OF MEMORY FOR
1410        STX NEXT+1   ; 1 ST STACK MOVE
1420 *
1430        LDX /STKRES-1 ; INIT STACK "BOTTOM"
1440        STX $1FC      ; TO POINT TO
1450        LDX #STKRES-1 ; STACK RESTORE
1460        STX $1FB      ; ROUTINE
1470        LDX #$FA      ; AND INIT
1480        TXS           ; STACK POINTER
1490 *
1500 *//////////////////////////////////
1510 *///                             ///
1520 *///    STACK CHECK ROUTINE      ///
1530 *///                             ///
1540 *///    JSR STKCHK AS 1 ST       ///
1550 *///    INSTRUCTION OF A         ///
1560 *///    RECURSIVE PROCEDURE.     ///
1570 *///                             ///
1580 *//////////////////////////////////
1590 *
1600 STKCHK .EQ *
1610 *
1620        TSX          ; CHECK STACK FOR OVERFLOW
1630        CPX #STKMIN  ; ENOUGH SPACE ?
1640        BCC STKSAV   ; NO, GO SAVE STACK
1650        RTS          ; YES, JUST RETURN
1660 *
1670 STKSAV .EQ *
1680 *
1690        LDY NEXT     ; SAVE LINK
1700        STY $1FE     ; TO
1710        LDY NEXT+1   ; STACK PAGE IN
1720        STY $1FF     ; MAIN MEMORY.
1730 *
1740        INY          ; SKIP UP TO NEXT PAGE
1750        CPY TOP+1    ; CHECK FOR COLLISION WITH
1760 *                   ; STUFF AT HIGH END OF MEMORY
1770 *
1780        BCC STKSV1   ; NO COLLISION, GO MOVE STACK.
1790        JMP MEMFUL   ; GO TELL BAD NEWS.
1800 *
1810 STKSV1 .EQ *
1820 *
1830        STY NEXT+1   ; SAVE POINTER
1840        INX          ; SKIP OVER CURRENT
1850        INX          ; RETURN ADDRESS
1860        STX $1FD     ; AND SAVE CURRENT STACK POINTER.
1870 *
1880        LDY #0       ; INDEX FOR 256 BYTE MOVE
1890 STKSV2 LDA $100,Y
1900        STA (NEXT),Y
1910        DEY
1920        BNE STKSV2
1930 *
1940        PLA          ; NOW SET UP RETURN TO CALLER
1950        STA $1F9
1960        PLA
1970        STA $1FA
1980        LDX #$F8     ; RESET STACK POINTER TO POINT
1990        TXS          ; TO BOTTOM OF STACK ($FA) AFTER RETURN
2000        RTS          ; AND RETURN.
2010 *
2020 *//////////////////////////////////
2030 *///                             ///
2040 *///    STACK RESTORE ROUTINE    ///
2050 *///                             ///
2060 *//////////////////////////////////
2070 *
2080 STKRES .EQ *
2090 *
2100        LDY #0       ; INDEX FOR 256 BYTE MOVE.
2110 STKRS1 LDA (NEXT),Y
2120        STA $100,Y
2130        DEY
2140        BNE STKRS1
2150 *
2160        LDA $1FE     ; RESTORE LINK
2170        STA NEXT     ; TO NEXT
2180        LDA $1FF     ; STACK PAGE
2190        STA NEXT+1   ; IN MAIN MEMORY
2200 *
2210        LDX $1FD     ; RESTORE OLD
2220        TXS          ; STACK POINTER
2230        RTS          ; AND RETURN.
```

bolic locations NEXT and TOP, respectively.

Also, this implementation does not assume that stack pages in main memory are page aligned (ie: the stack area starts on a page boundary). If they were page aligned, the low byte of NEXT would always be 0. This would free an extra byte of stack space and simplify the STKCHK and STKRES routines by deleting the code that refers to the low byte of NEXT.

Finally, note that if an application requires several recursive procedures, then STKMIN should be marked as:

$$STKMIN = \max \{STKMIN_1, \ldots, STKMIN_N\}$$

where $STKMIN_i$ is the stack storage required by the *i*th recursive procedure. Alternatively, to avoid wasting time, program the STKCHK routine to check a table of STKMINs indexed by the Y register. The calling procedure identifies itself as the caller by setting the Y register to point to the appropriate table entry. Line 1630 in listing 1 would then be replaced by:

```
TXA
CMP MINTAB,Y
```

The stack-management routines written on an Apple II using the S-C II assembler are given in listing 1. (The S-C assembler is available from S-C Software, POB 5537, Richardson TX 75080.)■

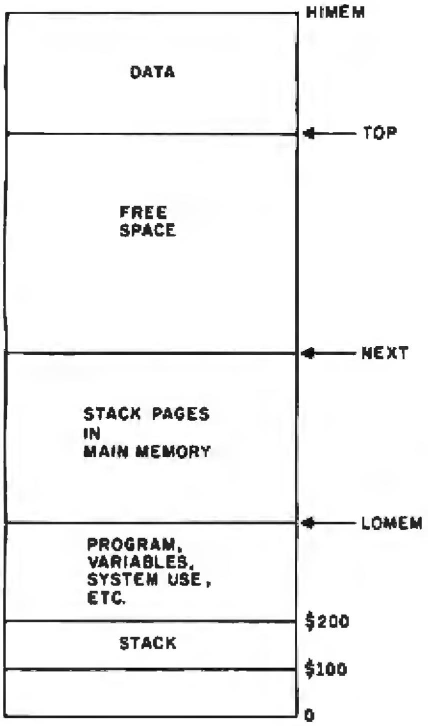


Figure 2: *This stack-management technique, developed on the Apple II, assumes system-memory management as shown here.*

Reference

1. Taft, S Tucker. "The Design of an M6800 LISP Interpreter." August 1979 BYTE, pages 132-152. Reprinted with complete 6800 assembly-language code for LISP interpreter as Document 112 in the BYTE Nybbles Library, now out of print.

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An Analysis of the Courseware Market

The 1981 Courseware Market Report is a reference book for companies and institutions preparing educational software. The report contains information on the creation and distribution of courseware and a competitive analysis of courseware materials. Market statistics, hardware and courseware suppliers, discussions of programming, and speculations on the future for computers in education are some of the topics covered in the study. The 1981 Courseware Market Report is available for $175 from Shotwell and Associates, 44 Montgomery St, Suite 505, San Francisco CA 94104, (415) 956-2273. Circle 504 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

What's New?

MISCELLANEOUS

Rockwell's 68000

Rockwell International's Electronics Devices Division has unveiled the R68000 16-bit microprocessor. The device addresses up to 16 megabytes, has more than 1000 instructions, and can process 8-, 16-, or 32-bit data. The R68000 can be sampled in 4 and 6 MHz versions; an 8 MHz version is under development.

Additional devices in the R68000 family will include a peripheral controller, a memory manager, a DMA (direct memory access) controller, and a multiprotocol communications controller.

The price for the 4 MHz R68000 is $210, the 6 MHz version is $220, and the projected cost of the 8 MHz device is $250. Contact Rockwell International, Electronic Devices Division, 3310 Miraloma Ave, POB 3669, Anaheim CA 92803, (714) 632-2321.

Circle 505 on inquiry card.

FORTH on a ROM

Martin Schaaf's full Z80 fig-FORTH on a ROM (read-only memory) replaces the BASIC ROM in the TRS-80 Model I. A screen editor, 8080/Z80 assemblers, and a metacompiler that reproduces FORTH from high-level code are included. The price is $250 from Martin Schaaf, POB 1001, Daly City CA 94017.

Circle 508 on inquiry card.

48 K-Byte Board for the Atari

The MM48001 is a 48 K-byte programmable-memory board for the Atari 400. It makes Atari 800 software compatible with the 400. The board costs $299. Contact Intec, Suite 111, 3387 Del Rosa North, San Bernardino CA 92404, (714) 864-5269.

Circle 499 on inquiry card.

ZEN and the Art of Programming

ZEN is an operating system in the North Star format using 5-inch floppy disks. The system includes a word processor with line justification, file creation, and search and insertions. The monitor comes with memory testing, repeat cross-functions, and port controls. The assembler has global labels, partial print designation, stops, and trial assembly. It is available for $75 from Zenrad Controls Company, 1575 A P S, Santa Barbara CA 93103, (805) 965-4996. **Circle 506 on inquiry card.**

System 6220 Counter/Timers

The System 6220 multifunction counter/timers can be combined to provide an array of display and control functions. Production quantities, flow, rotation, displacement, frequency, and elapsed time can be measured in process monitoring, test systems, and production control. Prices start at $115 for the 6222 counter/timer. Contact Newport Electronics Inc, 630 E Young St, Santa Ana CA 92705, (714) 540-4914. **Circle 509 on inquiry card.**

CP/M Business Software

Rocky Mountain Software Systems has a complete business-software system available for $199. The system is comprised of four software packages: General Ledger, Accounts Receivable, Accounts Payable, and Payroll. Written in MBASIC, the system will run on any CP/M-based microcomputer with at least 48 K bytes of programmable memory. Individual packages can be purchased separately for $59. Contact Rocky Mountain Software Systems, POB 3282, Walnut Creek CA 94598.

Circle 512 on inquiry card.

Computer Pollution Control

Electronic Specialists Inc, 171 S Main St, Natick MA 01760 (617) 655-1532, has announced Super Isolator, a device designed to control electrical spikes, surges, and noise. Super Isolator features three individually filtered AC sockets. Equipment interactions and disruptive or damaging power-line pollution are controlled. The Super Isolator controls pollution for an 1875 W load. Each socket can handle a 1000 W load. The Model ISO-3 Super Isolator costs $94.95.

Circle 507 on inquiry card.

Memory Boards for the Atari

The AT-16, a 16 K-byte, 200 ns memory board, and the AT-32, a 32 K-byte, 200 ns board, are compatible with all existing Atari 400 and 800 software and hardware. They install with no modifications. The AT-16 costs $119.50, and the AT-32 costs $199.50. Contact Microtek Peripherals Corporation, 9514 Chesapeake Dr, San Diego CA 92123, (800) 854-1081; in California (714) 278-0630.

Circle 510 on inquiry card.

TRS-80 Space Raiders

Space Raiders is a machine-language program that creates a detailed simulation of outer space combat. Current and target position, fuel, shield energy, and heading are all displayed. There are five levels of play.

Space Raiders runs on 16 K-byte Level II TRS-80 Model I microcomputers. It is costs $24.95. Contact Bosen Electronics, 445 E 800 North, Spanish Fork UT 84660, (801) 798-9553.

Circle 513 on inquiry card.

What's New?

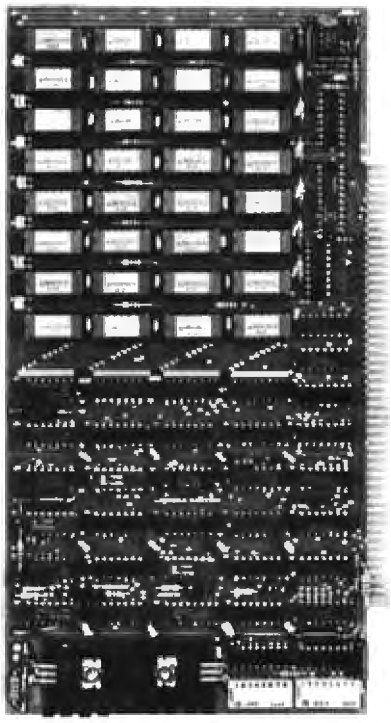
MISCELLANEOUS

64 K-Byte Board for S-100 Systems

The CI-S100 memory board is designed specifically for Sol, Cromemco, North Star, and other S-100 systems. The 64 K-byte dynamic board doesn't require WAIT states at 2 or 4 MHz. It is addressable in 4 K increments up to 512 K bytes. Features include expandability to 512 K bytes with a bank-select feature that allows users to select up to eight 64 K-byte cards. The hidden refresh does not interfere with block DMA (direct memory access) WRITE applications.

The CI-S100 costs $575. Contact Chrislin Industries Inc, 31352 Via Colinas 102, Westlake Village CA 91361, (213) 991-2254.

Circle 541 on inquiry card.



2 K-Byte ROM from Motorola

The MCM65516L43M is a 2 K-byte CMOS (complementary metal-oxide semiconductor) ROM (read-only memory). It is compatible with CMOS microprocessors that share address and data lines. The output-enable pin can be programmed for active high or low, or MOTEL (ie: MOTorola, inTEL) mode, which provides compatibility with Motorola's 6800 series or Intel's 8085 microprocessors. A monitor program for the Motorola CMOS MC146805E2 microprocessor is included on this ROM. Contact the MOS Integrated Circuit Division, Motorola Semiconductor Products Inc, Austin TX 78721, (512) 928-6660.

Circle 542 on inquiry card.

Programmable Array-Logic Designers Kit

PALKIT is designed to acquaint engineers with the Programmable Array Logic (PAL) family of integrated circuits. PAL circuits are used to reduce the number of 5400 and 7400 series components needed in circuit designs. By combining functions of TTL (transistor-transistor logic) devices, PAL circuits can reduce total package count by as much as 12 to 1.

The kit contains one preprogrammed master PAL circuit and seven unprogrammed circuits. Four of the unprogrammed devices are for combinatorial functions. The other three are for sequential functions. A PAL data sheet, instructions for programming, a paper tape, and an engineering reference card are included. The PALKIT is available for $99.95 from Monolithic Memories, 1165 E Arques Ave, Sunnyvale CA 94086, (408) 739-3535.

Circle 543 on inquiry card.

EPROM Programming

Logic Technology Services Inc (LTSI) is offering an EPROM (erasable programmable read-only memory) programming service. A program from a master EPROM, truth table, or paper tape can be reproduced to a compatible device, which is provided by LTSI. The service can be performed for 2704/2708s, 2716s, 2732s and 2764s.

Fees range from $9.95 to $45.95, depending upon EPROM. EPROMs can be erased for $0.25 per device. A truth table for reproduction can be entered for an additional $15 per 1000 words. A nonreturnable copy of the truth table should be provided. Quantity prices are available to clients who provide the components.

For details, contact Logic Technology Services Inc, 2400 E Oakton, Arlington Heights IL 60005, (312) 364-4670.

Circle 544 on inquiry card.

Fiber-Optic Transmitter and Receiver Modules

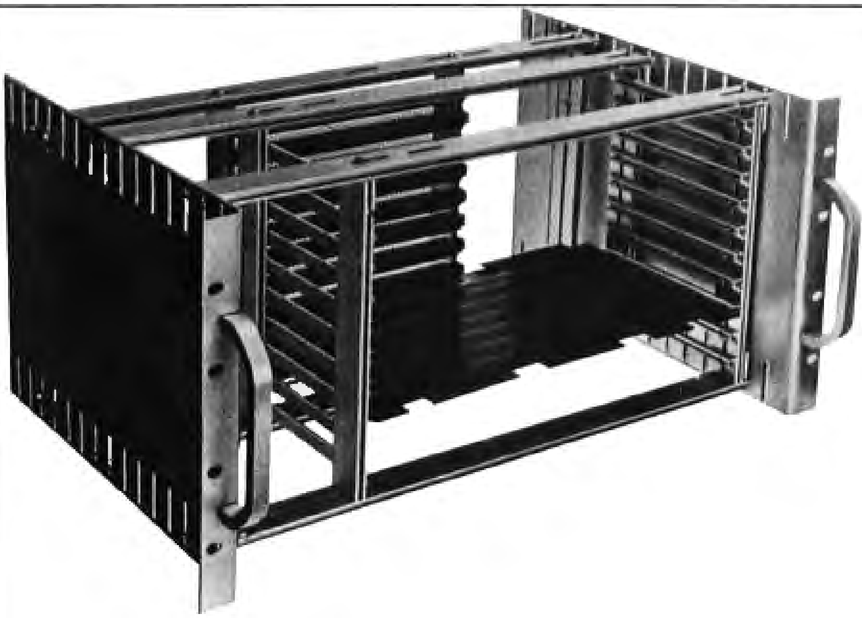
The MFOLO2T fiber-optic transmitter and the MFOLO2R receiver modules are designed for digital-communication systems. The transmitter module incorporates an LED (light-emitting diode) with an output of 70 μW, which can provide data transmission over a distance of 1 kilometer; greater distances can be achieved with other cables and emitters. The receiver has a bandwidth from DC to 200 kbps (bits per second), a dynamic range of 25 dB, and is TTL- (transistor-transistor logic) compatible. The modules are compatible with plastic- or glass-fiber cable and operate from a single +5 V supply. Full-duplex, star, daisy chain, and other system designs can be achieved.

The MFOLO2T costs $36.80, and the MFOLO2R costs $42.50. Contact Motorola Semiconductor Products Inc, POB 20912, Phoenix AZ 85036, (602) 244-4556.

Circle 545 on inquiry card.

What's New?

MISCELLANEOUS



Universal Card Cage

The CCK-80 card cages let designers package systems using Series-80 Multibus, S-100, Motorola, and Rockwell microcomputers and accessory cards. The fully adjustable, ten-board cages are priced at $79 each.

Additional space along the side of each cage can hold two fans and can be used for power supplies or other equipment. The rear cross members accept card-edge connectors or motherboards. The cage fits any standard 19-inch rack and weighs five pounds.

Cage accessories include card-edge connectors, bottom- and side-hinged front panels, latches, screw-attached front panels, top and bottom covers, handles, and tilt-up feet. Contact Vector Electronic Company, 12460 Gladstone Ave, Sylmar CA 91342, (213) 365-9661.

Circle 514 on inquiry card.

64 K-Byte Static Memory Board for the S-100 Bus

The RAM 17 is a 64 K-byte static board for S-100 microcomputers. It is guaranteed to run with 6 MHz Z80s and 10 MHz 8086/8088s. The board features power dissipation of less than 2 W and 24-bit addressing. The RAM 17 can be addressed on any 64 K page boundary and can be disabled in 16 K blocks. The upper 8 K block can have 2 K windows disabled for memory-mapped peripherals.

RAM 17 uses 2 K by 8-bit static integrated circuits that are compatible with 2716 EPROMs (erasable programmable read-only memory). Prices range from $1095 to $1595. Contact CompuPro, Godbout Electronics, POB 2355, Oakland Airport CA 94614, (415) 562-0636.

Circle 516 on inquiry card.

Keyboard Actuator

When interfaced with microcomputers, such as the TRS-80, PET, or Apple, the KGS-80 keyboard actuator turns IBM Selectric and SCM typewriters into printers. The KGS-80 rests on the typewriter keyboard and plugs into the computer's printer interface. No modifications are necessary and no software is required to operate the device. Details on this $599 peripheral can be obtained from Kogyosha Company Ltd, 179 Riveredge Rd, Tenafly NJ 07670, (201) 569-8769.

Circle 515 on inquiry card.

Prevent Static Damage

Wescorp has static-dissipative desk and bench covers of soft vinyl to protect products from static electricity damage. The WS-227-18 Stat-Mat reduces vibration and glare and is water and chemical resistant. Static resistance meets DOD (Department of Defense) handbook specifications. The covers are available in 2- and 4-foot widths cut to any length up to 100 feet. The cost is $4 per square foot.

Conatct Wescorp, 1155 Terra Bella Ave, Mountain View CA 94043, (415) 969-7717.

Circle 517 on inquiry card.

Color-Graphics Display Controller

The NEC μPD7220 integrated circuit operates between the video-display memory and the microprocessor bus. It performs most of the tasks required to generate displays and to manage display memory. Compatible with 8080/8085/8086, Z80, 6800, and other processors, the device minimizes host-processor software overhead. It features DMA (direct memory access) control, graphics figure-drawing capabilities, and a light-pen input. The unit has a 5 MHz clock rate and requires a single +5 V supply.

Samples of the μPD7220 are priced below $100. Contact NEC Microcomputers Inc, 173 Worcester St, Wellesley MA 02181, (617) 237-1910.

Circle 518 on inquiry card.

What's New?

PUBLICATIONS

Catalog of More Than 2000 Rental Items

Genstar Rental Electronics Inc. which specializes in the short-term rental of elelctronic equipment, has a free catalog that lists its rental items. The catalog is divided into 47 categories that range from amplifiers to test chambers. There are analyzers, generators and meters of all types, plus microcomputers, microprocessor instrumentation, PROM (programmable read-only memory) programmers, oscilloscopes, and data terminals. For your copy, contact Genstar Rental Electronics Inc, 19527 Business Center Dr, Northridge CA 91324, (213) 993-7368.

Circle 519 on inquiry card.

Directory of Robotics Products

The Robotics Industry Directory contains a summary of the available products in the robotics industry. Robots, robot subsystems, components, general technical specifications, pricing data, and marketing contacts are featured. Also included is information on consulting firms, personnel recruiting, engineering design, systems integration, and custom-manufacturing. The final section provides information on the activities of public organizations, university research, and private research laboratories. The Directory costs $24.95. Contact Robotics Industry Directory, POB 725, La Canada CA 91011, (213) 352-7937.

Circle 520 on inquiry card.

Man/Machine Communications

Speech Technology is a quarterly magazine concerning man and machine communications. It deals with the state of the art in voice synthesis and recognition for the engineer, scientist, educator, manager, and other users. Articles on linear-predictive coding, adding word recognition to a system, and new applicatons, such as a voice-activated door lock, are among the topics covered. New products, events, and a newsletter are also featured. A one-year subscription is $50 from Media Dimensions Inc, 525 E 82nd St, New York NY 10028, (212) 680-6451.

Circle 521 on inquiry card.

What's New?

PUBLICATIONS

S-100 Products Catalog

Ackerman Digital Systems Inc, the maker of processor boards and other items for S-100 systems, has published a catalog of its products. Music and 6809 processor boards, PROM (programmable read-only memory) programmers, and other devices are described in the catalog. For a copy, contact Ackerman Digital Systems Inc, 110 N York Rd, Elmhurst IL 60126, (312) 530-8992.

Circle 523 on inquiry card.

Electronic Learning

Electronic Learning magazine is a bimonthly publication for educators who buy and use electronic hardware and software in elementary and secondary education. A nontechnical source of ideas and information, it includes articles on the use of microcomputers, video cassettes, videodiscs, and other aids in education. For more information, contact Scholastic Inc, 50 W 44th St, New York NY 10036, (212) 944-7700.

Circle 524 on inquiry card.

Looking for a Certain Publication?

The Westlake Guide lists periodicals and offers package subscriptions for computer, electronics, video, telecommunications, and business publications. A copy of the guide costs $1. Contact Westlake Subscription Service, 4200 S Louise, Sioux Falls SD 57106, (605) 331-6930.

Circle 522 on inquiry card.

Apple Software Directories

Apple Software Directories is a three-volume set that lists available business, games, and educational software for Apple computers. It includes the names and addresses of more than 400 software vendors.

The Apple Softare Directory—Volume 1: Business Guide costs $5.95. Volume 2: Games Directory costs $4.95. Volume 3: Educational Guide costs $5.95. Contact WIDL Video, 5245 W Diversey, Chicago IL 60639, (312) 622-9606.

Circle 526 on inquiry card.

UNIX Products List Available

A directory of UNIX and C products is now available on a subscription basis from InfoPro Systems. The UNIX software list includes suppliers of UNIX, C compilers and interpreters, data-base systems, other languages on UNIX, applications and business packages, user groups, utilities, hardware vendors, and UNIX-like systems. A yearly subscription to the UNIX Software List is $18. For details, contact InfoPro Systems, POB 33, East Hanover NJ 07936, (201) 625-2925.

Circle 527 on inquiry card.

Computers in Science Teaching

The Journal of Computers in Science Teaching is a quarterly publication on the use of computers in science instruction. It features research studies on teaching science and tutorials. There are lists and reviews of science software, announcements of conferences and events, and book reviews. The Journal of Computers in Science Teaching is published by the Association for Computers in Science Teaching, POB 4825, Austin TX 78765, for $7 per year.

Circle 525 on inquiry card.

Computer Merchandising

Computer Merchandising covers sales and manufacturing in the computer industry. It investigates the ebb and flow of the educational computer marketplace, peripherals, and promotions to increase sales. Interviews with people in the industry are also featured. This monthly publication costs $18 per year and is available from Computer Merchandising Magazine, 15720 Ventura Blvd, Suite 610, Encino CA 91436, (213) 995-0436.

Circle 529 on inquiry card.

Educational Computer

Educational Computer is an information exchange for elementary, high school, college, and university students and educators. In its pages, Educational Computer addresses such topics as the impact of microcomputers in schools, colleges, and universities. Also, separate departments feature letters from readers, editorials, book reviews, events, classified ads, and administrative feedback. The yearly subscription rate (6 issues) is $12. Contact Educational Computer Magazine, POB 535, Cupertino CA 95015, (408) 252-3224.

Circle 530 on inquiry card.

IEEE Publications Catalog

A publications catalog is available from the Computer Society of the IEEE (Institute of Electrical and Electronics Engineers). The catalog lists more than 300 publications and covers all aspects of applications, methodologies, and techniques in computer software and hardware. It also contains technical-level tutorial texts for the computer scientist and engineer. For a free copy of the 1981 *Pubs Catalog*, write to the Computer Society Press, POB 639, Silver Spring MD 20901.

Circle 528 on inquiry card.

U.S. MICRO SALES

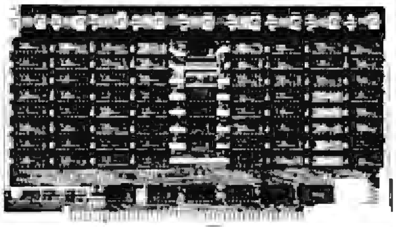
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This is ABSOLUTELY the LOWEST PRICE EVER for a Hi Speed (300 NS) LO-LO Power 32K RAM. 4K by 1 Chips are organized in Selectable Banks.

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* *9 Regulators*

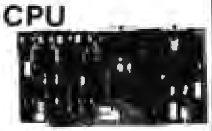
$250 (KIT)



S-100 BOARDS and ACCESSORIES



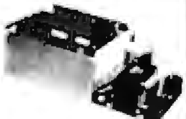
Z — 80 CPU



The first time this world popular CPU offered in Kit. Two serial, 3 parallel, CTC, EProm Z-80 at 4 mhz. Software buad rate, etc. (Less Prom. & Cable) **$250.00**

S1 — MOD (KIT)

$199.00 MADE IN USA



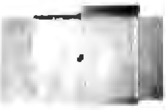
Complete S-100 12 Slot Computer. Ample system power with regulated power for drives. Excellent for Subsystem or Hobby use. Four hours to build. (6 conn., incl., less fans)

S-100 CARD EXTENDER



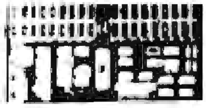
$12.50

(Gold Contacts)



As long as there is a price war, we will fight your battle. Compare at your local Department store and buy U$ MICRO.

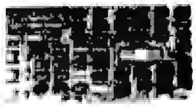
EXPANDABLE RAM
★ SPECIAL ★ SPECIAL ★



This is the best all around 64K board you can buy. If after you see it, you don't agree return for full refund. Bank Select by extended address lines or I.O. 40H.

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Double Density 8" and 5" Disk Controller designed for S-100 IEEE standards. Uses Western Digital 1795, 1691, 2143 Chip Set.

S-100 - CONNECTOR
TI or Better



SOLDER TAIL **$2.50**

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* 2810 CPU Only — $250.00
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* 2065C 64K Only — $425.00
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* 2718 2x2 Only — $305.00
* 2200A Mainframe Only — $349.00
* 2501 Mother Board Only — $106.00
* 2116C 16K Static Ram 200ns Only — $309.00
* 2520K Extender Board Only — $ 52.00

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Z - 80 - A
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4MHZ Beastie with extra instructions!

Z-80 SUPPORT

CTC — $6.55
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PIO — $6.50
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All 4MHZ (who wants 2MHZ ?)

2716s $7.75 (450 NS)
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Remember when 2716s were $50.00 and hard to get? These units are so beautiful it's hard to part with them. But we will, for a small price. Guaranteed!

2114s **$2.75 ea.**



One of the world's two most popular STATIC RAMs. Factory prime tested units. Sold in lots of 8 only. FUJITSU, HITACHI, etc. **200 NS**

4116s

Expansion 16K Dynamic RAMs for Apple, TRS-80 S-100 systems. T.I., Mostek Intel. Call for manufacturer. **$2.50** **200 NS**

TMS — 4044
MM — 5257
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The other of the world's most popular STATIC RAMs This one is 4K by 1 organization.

U.S. Micro Sales can also supply a vast array of IC's.
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We can also supply power supplies - sockets - heat sinks - tools etc., etc., etc.

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What's New?

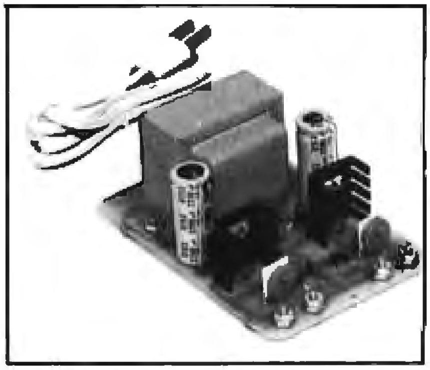
MISCELLANEOUS



Votrax Speech Circuit

The SC-01 speech-synthesizer integrated circuit combines electronically generated phonemes to produce an unlimited vocabulary. Votrax's technique doesn't limit the number of words and phrases to a fixed amount or format as synthesizers that reconfigure words and phrases from prerecorded human voice tracts do. Designers can build their own vocabulary through a system that contains an algorithm that automatically translates English text into phonemes. One second of speaking time requires 70 to 100 bits of memory with this device.

The speech-synthesizer chip is available at prices starting at $95 each, for a minimum of five units. The Vodex Sales Division of Votrax Inc is located at 500 Stephenson Hwy, Troy MI 48084, (800) 521-1350; in Michigan (313) 588-0341.
Circle 536 on inquiry card.



5 to 15 V DC Dual Power-Supply Kit

The JE215 power-supply kit provides adjustable regulated positive and negative output voltages from 5 to 15 V DC. Power output for each supply ranges from 5 V DC at 500 mA to 15 V DC at 175 mA. The JE215 kit retails for $24.95 from Jameco Electronics, 1355 Shoreway Rd, Belmont CA 94002, (415) 592-8097.
Circle 540 on inquiry card.

Switched-On DOS

The DOS Switch allows a DOS-3.3-equipped Apple II to boot either DOS 3.3 or 3.2 floppy disks without need of the BASICS disk. The switch doesn't require support software or modifications to established 3.2 disks. The device plugs into the Apple without soldering or permanent wiring changes. The DOS 3.3 P5A boot PROM (programmable read-only memory) and the DOS 3.2 P5 boot PROM are needed for installation. The DOS Switch costs $29.95 and is available from the Micro Computer Center, 7900 Paragon Rd, Dayton OH 45459, (513) 435-9533.
Circle 537 on inquiry card.

Aid for the Physically Disabled

The Viewpoint Optical Indicator is an incandescent lamp mounted onto a headband. It enables the physically disabled individual with good head control to indicate objects, words, or symbols on a manual-communication board. The band can be worn on the head, hand, or wrist. The lamp can be positioned for use in a wheelchair, bed, or on a prone board. A rechargeable power-pack stores a day's charge. The device costs $189 and is available from Prentke Romich Company, RD 2, POB 191, Shreve OH 44676, (216) 567-2906. Circle 538 on inquiry card.

PROMs with Titanium-Tungten Fuses

Monolithic Memories' line of 1 K- and 2 K-byte PROMs (programmable read-only memories) uses titanium-tungsten (TiW) fuses and requires only 70 mA of current with no loss in speed. Access times are 55 ns for the 1 K PROM and 60 ns for the 2 K device. Pin-compatible with standard Schottky PROMs, these units are organized as 256- by 4-bit and 512- by 4-bit arrays. The PROMs have full Schottky clamping, three-state or open-collector outputs, and transistor inputs for low-input current. A new programming technique eliminates the need for a separate programming pin as found on Nichrome-fused PROMs.

Prices range from $3.75 to $10.55. Contact Monolithic Memories, 1165 E Arques Ave, Sunnyvale CA 94086, (408) 739-3535. Circle 539 on inquiry card.

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FOR TRS-80* Model I

CCI-100	5¼", 40 Track (102K)	$299

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External card edge and power supply included. 90 day warranty/one year on power supply.

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DISKETTES — Box of 10

5¼"	Maxell $40		BASF/Verbatim	$26.95
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PLASTIC FILE BOX–Holds 50 5¼" diskettes				$19.00
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FLOPPY SAVER	$10.95		RINGS	$ 6.95

16K RAM KITS

2 for $37 **$19**

200ns for TRS-80,* Apple II, (specify): Jumpers $2.50

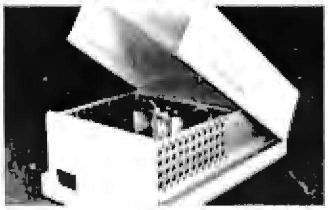
SYSTEM SPECIAL

Apple II Plus 48K w/drive and controller. Epson MX-80 printer and interface. SUP-R Mod RF Modulator: List $2965 You Pay $2299

COMPUTERS/TERMINALS

ARCHIVES	64K, 2-Drives, 77 Track			$CALL
ALTOS	ACS8000 Series			$ CALL
ZENITH	48K, all-in-one computer			$2200
ZENITH	Z-19			$ 725
TELEVIDEO	910 $559	920C $ 729	950	$1039
IBM	3101 Display Terminal			$1189
ATARI	400 $ 359		800	$ 795
MATTEL	INTELLIVISION			$ 259
APPLE PERIPHERALS				$ CALL

S-100 CALIFORNIA COMPUTER SYSTEMS





MAINFRAME	Model 2200A	$349
Z80 CPU	Model 2810	$259
MOTHER BOARD	Model 2501	$106
16K STATIC RAM, 200ns	Model 2116C	$309
32K STATIC RAM, 200ns	Model 2032C	$619
64K DYNAMIC RAM	Model 2065C	$580
FLOPPY DISC CONTROLLER	Model 2422A	$345
EXTENDER BOARD	Model 2520K	$ 52
2P + 2S I/O	Model 2718A	$309

PRINTERS



NEC SPINWRITER
Letter Quality High Speed Printer

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	13" Color	$329		
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Circle 107 on inquiry card.

MISCELLANEOUS

High-Resolution Touch Screens

With the TSD 12- and 15-inch Touch Screen Digitizers, you can enter data by touching a computer display with your finger. The screen's high-resolution also permits the entry of graphic data. The Touch Screens can be retrofitted onto existing video displays, and in most cases no modifications are necessary. The thin, transparent, curved panel, consisting of two conductive films separated by an insulating space, mounts in front of the video display; an interface board is connected to the panel with a cable. When the panel is touched, one conductive layer touches the other, yielding a voltage that is converted into the necessary information and transmitted as an RS-232C message or a parallel 8-bit, 3-state message.

The 12-inch model costs $650 and the 15-inch device is priced at $700. Contact TSD Display Products Inc, 35 Orville Dr, Bohemia NY 11716, (516) 589-6800.

Circle 531 on inquiry card.

16 K-Byte Programmable Memory Circuits

Fujitsu Microelectronics has a family of 16 K-byte dynamic programmable-memory integrated circuits with single 5 V power-supply requirements and access times as fast as 100 ns. The MB8117 and MB8118 devices are available with 100 or 235 ns cycle times.

Features include 182 mW power dissipation, bias generator, read-write-modify, hidden refresh, page-mode capability, and TTL- (trasistor-transistor logic) compatible inputs. Contact Fujitsu Microelectronics, 2945 Oakmead Village Ct, Santa Clara CA 95051, (408) 727-1700.

Circle 532 on inquiry card.

EPROM Has High Standards

Advanced Micro Devices has a 32 K-bit EPROM (erasable programmable read-only memory) that meets the MIL-STD-883 and INT-STD-123 quality standards. Organized as 4 K bytes by 8 bits, the Am2732 operates from a single +5 V supply. It offers three-state outputs, fully static operation, and a two-line control that makes Chip Enable and Output Enable available. This eliminates bus contention and the need for external buffers and chip controls.

The Am2732 costs $31.50. Contact Advanced Micro Devices, 901 Thompson Pl, Sunnyvale CA 94086, (408) 732-2400.

Circle 533 on inquiry card.

In-Circuit Microcomputer Tester

Patuck Inc's microcomputer analyzer is a hand-held device that clips directly to the microprocessor to be tested by means of a 40-pin chip clip. It can single-step the microprocessor or let it run free to a selected error vector or trap address. A trace capability allows examination of the 63 machine cycles that precede breakpoint. Interchangeable interfaces are available for Z80-, 8080/85-, 6502-, 6800-, 2650-, 6802-, and 6501-based microcomputers.

The Microcomputer Analyzer costs $829. Interfaces are $61 each. Contact Patuck Inc, 5073 Russell Ave, Pennsuaken NJ 08109, (609) 662-0677.

Circle 534 on inquiry card.

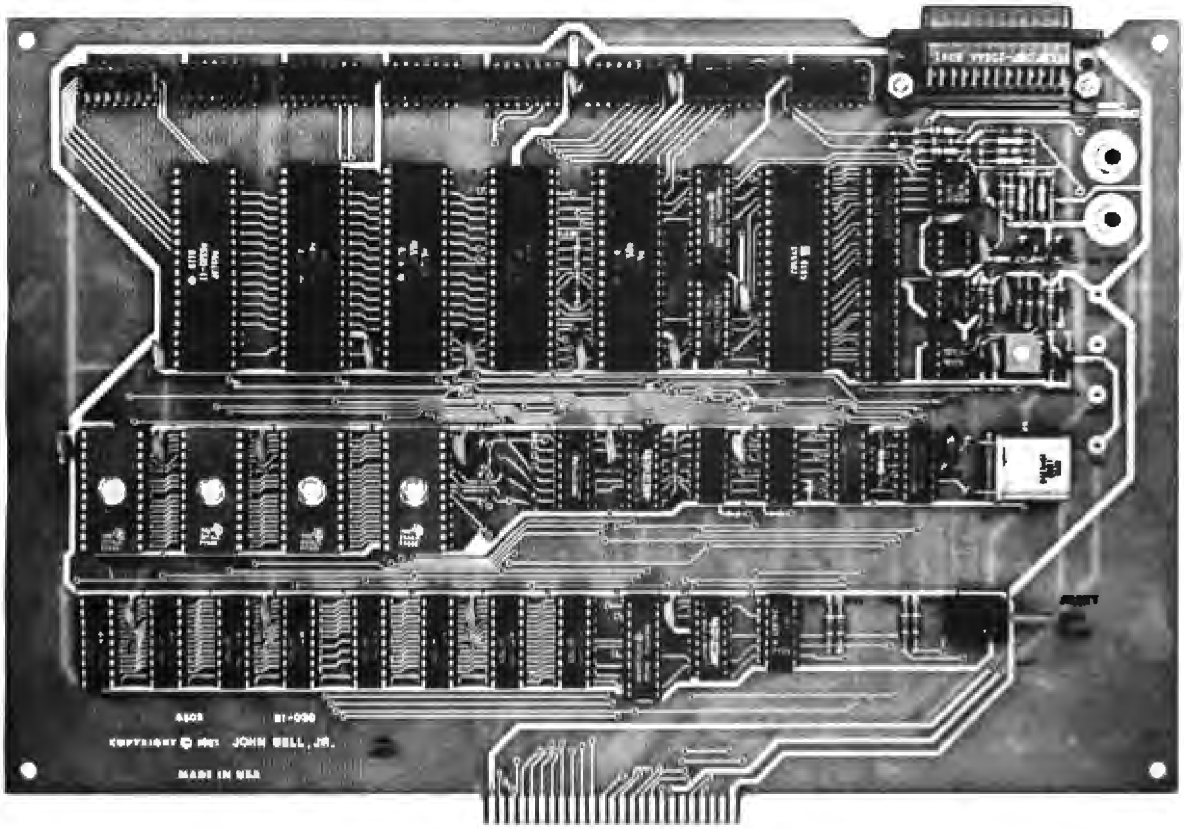


PROM Copier/Verifier

The cloneAprom PROM (programmable read-only memory) copier/verifier duplicates a 5 V master 2716 EPROM (erasable PROM) in 138 seconds. It features two ZIF (zero insertion force) sockets, pass/fail indicators, and a power supply. Both a 2732 and a 220 VAC, 50 Hz version are available.

The cloneAprom costs $299. Contact Alloy Engineering Company Inc, 12 Mercer Rd, Natick MA 01760, (617) 655-3900.

Circle 535 on inquiry card.



What's New?

SYSTEMS



Microlite Microcomputer

The Microlite microcomputer is a self-contained system that includes the microprocessor, keyboard, 24-line by 80-character plasma display, and two 5-inch floppy-disk drives capable of storing up to 350 K bytes. Microlite has provisions for serial communications.

Options for the Microlite include a dot-matrix printer that can be housed in the console and support for up to four 8-inch floppy-disk drives. Hard-disk drives are also available. For more information on the Microlite II, contact Q1 Corporation, 125 Ricefield Ln, Hauppauge NY 11787, (516) 543-7800.

Circle 590 on inquiry card.

Pascal Development System for CP/M

The PDS-80 Pascal Development System for CP/M applications is designed with the systems integrator and applications-software developer in mind. A Cache BIOS for CP/M uses the DMA (direct-memory access) and interrupt capabilities of the disk controller and memory to buffer whole tracks in extended memory, which speeds up execution times.

Included in the system is Pascal/Z, a native-code compiler that generates ROMable (read-only memory) and reentrant object code, relocatable object modules, and permits separate compilation. A 2.4-megabyte dual-disk drive, choice of mainframe, Cache BIOS, Pascal/Z, and CP/M come with the development system. Five utilities are also included: InterEdit, a screen-oriented editor; Spell, a spelling editor with a 10,000-word modifiable dictionary; Quickopy, for copying disks faster than the PIP utility; Help, an access to documentation; and Compare, a quick view of the difference between two files.

The PDS-80 Development System costs $7995. Contact Ithaca Intersystems Inc, 1650 Hanshaw Rd, Ithaca NY 14850.

Circle 591 on inquiry card.

Omninet from Corvus

Omninet is a 1-megabyte-per-second network that uses a shielded twisted-pair cable for connecting microcomputers. The network allows the interconnection of up to 64 microcomputers and peripherals in a 4000-foot serial link. The intelligent component of the system is the Omninet transporter, which interfaces to the microcomputer or peripheral and provides for the transfer of messages without software intervention or requiring a control processor. Omninet will work with Corvus Constellation software, providing up to 80 megabytes of shared storage.

Available for the Apple II, Onyx C8000, and Digital Equipment Corporation LSI-11 computers, Omninet will also connect to all Corvus peripherals. Future transporters are being designed for TRS-80, Apple III, S-100, Atari, Commodore, Altos, and other popular microcomputers.

Omninet transporter units are priced at $495 for the Apple II and S-100, $750 for LSI-11 computers, and $650 for the Onyx C8000. A disk server for Corvus Winchester disks will retail for $990. For more information, contact Corvus Systems Inc, 2029 O'Toole Ave, San Jose CA 95131, (408) 946-7700.

Circle 592 on inquiry card.

Datamac Series 1200

The Datamac 1200 series of microcomputers can be expanded with external floppy-disk drives of any density, track, or side configuration. Provision is made for using the video display to set breakpoints and single-step through programs for debugging. Among the models available is the 1255 microcomputer. It contains a Z80 microprocessor, 64 K bytes of programmable memory, input/output ports, keyboard, video display, dual 5-inch double-sided double-density disk drives, and the CP/M operating system.

The Model 1255 with two drives capable of storing 780 K bytes lists for $4695. Contact Datamac Computer Systems, 3333-F Octavius Dr, Santa Clara CA 95051, (408) 727-0561.

Circle 593 on inquiry card.

10 MHz 68000

Motorola Semiconductor Group has announced the availability of a 10 MHz MC68000L10 microprocessor. Samples are available for $449. Contact your local Motorola representative or the Motorola Semiconductor Group, 3501 Ed Bluestein Blvd, Austin TX 78721, (512) 928-6119.

Circle 594 on inquiry card.

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Micromodem][	295
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CCS Asynchronous Serial Interface	159
Corvus 10 Meg. Hard Disk	4395
Corvus Constellation	595

MISCELLANEOUS/SUPPLIES

16K RAM (200-250 NS)	29
Verbatium Datalife Diskette (Box of 10)	30
Dysan Diskettes (Box of 5)	22
Apple Diskettes (Box of 10)	45
Verbatim Diskette Boxes (Holds 50 Disks)	18
Silentype Paper (Box of 10 rolls)	40

MONITORS/DISPLAYS

Leedex Video 100 12"	140
Sanyo 9" Monitor	195
KG-12C Green Phos. Monitor	275
Sanyo 12" Green Phosphor. Monitor	275
NEC 12" Green Phosphor. Monitor	275
Sanyo 12" B/W Monitor	250

PRINTERS

Apple Silentype with Interface	525
IDS 445 (Paper Tiger) with Graphics	650
IDS 460 with Graphics	1049
IDS 560 with Graphics 10)	1199
Centronics 737	795
NEC Spinwriter (RO, Serial)	2650

SOFTWARE

The Controller	525
Apple Post (Mailing List Program)	45
Easywriter Professional System	195
Apple Pie 2.0	110
DB Master Data Management	175
The Cashier	210
Apple Writer	65
Visicalc	175
CCA Data Management System	90
Full Screen Mapping for CCA DMS	59
Pascal Interactive Terminal Software (PITS)	29
Basic Interactive Terminal Software (BITS)	29
Data Capture	45
Data Factory DMS	110
Apple Plot	55
Apple Pilot	120
Magic Wand Word Processor (Needs Z-80 Softcard)	345
Dow Jones Portfolio Evaluator	45
Fortran	140

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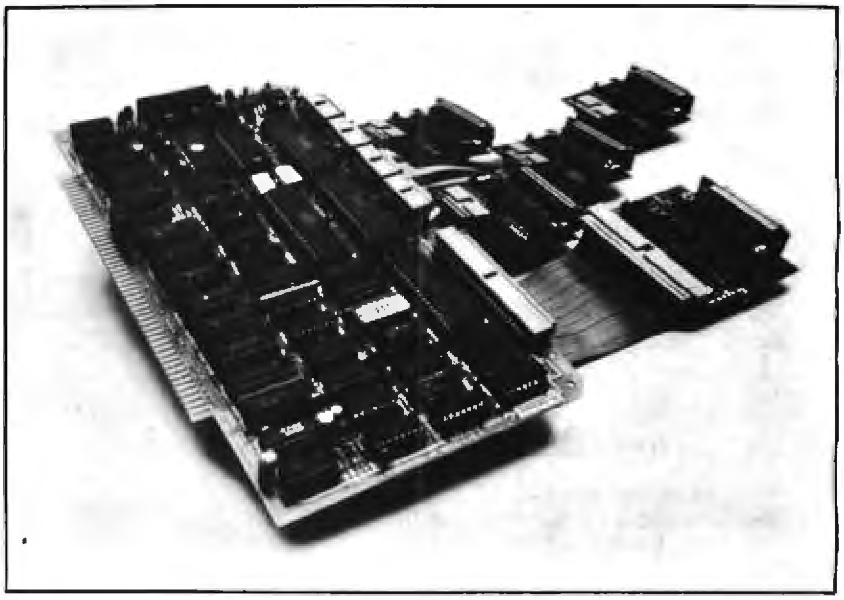
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COMPUTER STOP, 2545 W. 237 St., TORRANCE, CA 90505

What's New?

SYSTEMS

New Z80 Board

The CPC-2810 Z80-based processor board is designed for the S-100 bus. It features two or four serial I/O (input/output) channels, software-selectable data rates, two parallel I/O channels with handshaking, eight vectored priority interrupts, and compatibility with most disk controllers. All asynchronous serial channels can be made fully synchronous. I/O interfaces are customized through the use of external personality boards. The CPC-2810 Z80 board costs $495 from Measurement Systems & Controls, 1601 Orangewood, Orange CA 92668, (714) 633-4460. Circle 595 on inquiry card.



A Very Portable Terminal

LEX 21 is a small, lightweight, low-cost printing and communications terminal. The LEX 21 terminal features a built-in modem, keyboard, and a thermal printer that displays upper- and lowercase characters. It measures 22 by 28 by 7.1 cm (8½ by 11 by 2¾ inches), weighs 2.25 kg (5 pounds), and takes up half a standard briefcase. Two K bytes of memory and a 1 K-byte line buffer are standard. The selectable transmission rates are 10 or 30 characters per second. The LEX 21 is designed for business and professional people for use in offices, homes, and when traveling. The LEX 21 costs $1195. Contact Lexicon Corporation, 8355 Executive Center Dr, Miami FL 33166, (305) 592-4404.
Circle 596 on inquiry card.



CBM 8032 Color Computer

The CBM 8032 microcomputer now has color. The Color 8032 features a 12-inch, 80-character by 25-line video display, 73-key upper- and lowercase keyboard, and numeric keypad. It also features a high-resolution RGB (red/green/blue) color monitor that displays eight colors in the text and graphics modes.

CBM 8032 software runs on the Color Computer without modification. Using the Control key, users can change foreground and background color combinations, or use reverse field for highlighting. In the graphics mode, the Color Computer provides 160 by 100 dot resolution. The computer contains a 32 K-byte screen edit ROM that provides color-handling capability. The CBM version 4.0 BASIC interpreter remains unchanged. Contact Commodore Business Machines Inc, 681 Moore Rd, King of Prussia PA 19406, (215) 337-7100.

Circle 597 on inquiry card.

What's New?

SYSTEMS

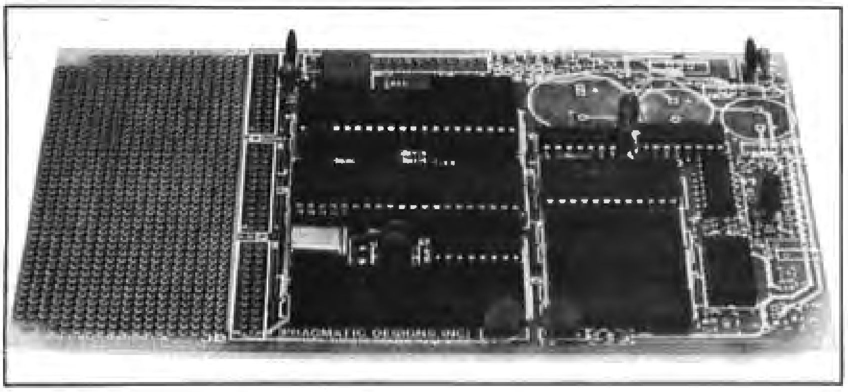
Multiuser System

The System/48 is a multiuser system for small- to medium-size businesses. It can accommodate up to eight simultaneous users and has 20 megabytes of Winchester hard-disk storage.

MAGIC is an operating system for the System/48. It provides a means for direct-indexed access to several billion bytes of storage. The DataMagic II is a data-base system that provides a screen formatter, the BASIC language, a report generator, and an edit, update, and query processor package. For complete details, contact TEI Inc, 5075 S Loop E, Houston TX 77033, (713) 738-2300.

Circle 598 on inquiry card.





Single-Board 8085 Computer

CPU-1 is an 8085-based microcomputer similar to the Intel 80/04 board. It is designed specifically for dedicated control applications. The system operates at 3 MHz and includes 256 bytes of programmable memory, 22 I/O (input/output) lines, one serial I/O port, one programmable counter/timer, and two sockets for 1 to 4 K bytes of EPROM (erasable programmable read-only memory). Only an external transformer is needed to complete the system. A printed-circuit board area is provided for user development. Applications programs for CPU-1 can be developed using any 8080/8085 development system.

The price for CPU-1 is $185. An expanded version with more memory and I/O lines costs $220. Contact Pragmatic Designs Inc, 950 Benicia Ave, Sunnyvale CA 94086, (408) 736-8670.

Circle 599 on inquiry card.

Econet Network

The Econet network system for interconnecting computers and peripherals uses a four-wire connector. It allows a separation of up to 1 kilometer between stations and is compatible with all Acorn (or other microcomputer) systems. A ten-station network with a 400 K-byte file station costs £3000 (approximately $6000); additional stations cost £50 (about $100). Up to 255 stations can be interconnected with a data transfer rate of up to 210,000 bps (bits per second). Collision-detect circuitry and a collision-arbitration algorithm minimize the need for retries. Econet hardware fits inside a computer, and the software resides in 4 K bytes of ROM (read-only memory).

Econet was primarily designed for schools and institutions, but it can be used in any environment. For more information, contact Acorn Computer Ltd, 4a Market Hill, Cambridge, CB2 3NJ, England. **Circle 600 on inquiry card.**

PRIORITY ONE ELECTRONICS

MICROPOLIS™ S-100 DISC DRIVE SUB SYSTEMS



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An ordinary 5¼" floppy provides just 35 tracks per side and stores only 70K bytes. This is not nearly enough for anything useful, so Micropolis uses 77 tracks per side. Each track is then formatted with 16 sectors (hard) at 256 bytes per sector, yielding an impressive 315K bytes per side.

Micropolis drives have a larger capacity than many 8" disk drives, though they only occupy the space of a 5¼" floppy. The 315K byte capacity is roughly 4 times the capacity of a standard 5¼" drive. This is what we call QUAD DENSITY.

To achieve the high density capability, you may think Micropolis had to sacrifice speed or reliability. NOT SO! The track to track access time is only 30ms with a high speed data transfer rate of 250,000 bits per second.

By creating this high density format, Micropolis is able to keep your initial subsystem costs to a minimum. Your cost is less than $.002 per byte. That's a BIG VALUE in a small package.



MICROPOLIS disk subsystems are expandable to keep up with your ever increasing needs. Up to four drives/heads may be daisy-chained on one S-100 controller board. With all four drives/heads in operation, you have access to over 1.2 MEGABYTES of on-line storage.

WITH MICROPOLIS, complete means COMPLETE. Each subsystem comes complete with controller interface, cable, and software. The software includes the MDOS operating system, extended basic, assembler and editor. MDOS is a complete package, including an assembler, editor, file management functions and utilities, which provides total support. BASIC is a self-contained package which provides a powerful set of tools for developing, testing, executing, and maintaining BASIC programs.

BASIC is designed for microcomputers with at least 24K bytes of RAM and Micropolis Metafloppy disk system. DOS can be used alone in a 16K byte memory system.

Activating the built-in Auto load ROM brings up the systems under control to the DOS executive. Basic can be accessed by issuing a simple DOS command.

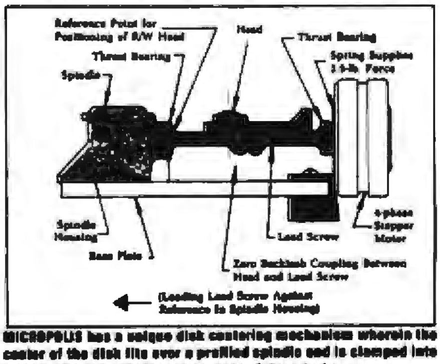
Both packages are designed for flexible, efficient programming. Both packages use the same file structure and file management scheme for total compatibility. Programs created under DOS can be loaded and accessed from BASIC. Data files created under BASIC can be processed by user written application programs running under the DOS. Everything you need to get "On Line" in one complete package.

MICROPOLIS provides total integration, which means they control everything from beginning to end. The result is a better drive for you, backed by a full 120 days factory warranty.

Anyone can cut price by lowering capacity or eliminating valuable features. But there's no long term advantage in it. Not for the user. Or the manufacturer.

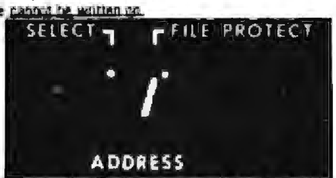
MICROPOLIS takes a better approach, even though it's more difficult, by using advanced design to provide more capability while lowering cost.

For example, most 5¼" floppy disks cut costs by using a less expensive, less accurate plastic cam or cam follower to position the read/write head. Most 8 inch floppy disks use a better approach, with a rolled steel lead screw for this function.



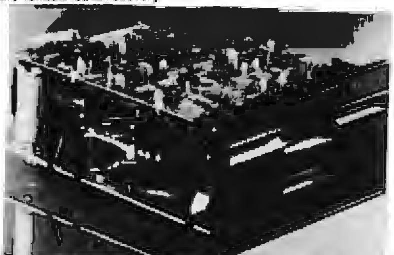
MICROPOLIS has a unique disk centering mechanism wherein the center of the disk fits over a profiled spindle and is clamped into place while the spindle rotates to assist centering.

MICROPOLIS goes them one better and uses an all-steel system, with a precision-ground steel lead screw and steel follower. It costs more but gives you greater storage capacity with lower cost per thousand bytes. Not so incidentally, the steel construction (compared to plastic) significantly increases reliability, too. There's even a built-in File Protect feature that prevents accidental loss of valuable data. (A file protected diskette cannot be written on.



Buy a dual drive Metafloppy and see the light. With our built-in LED that instantly indicates the drive selected, drive address, and File Protect.

Heat can cause numerous read and write errors that can become hazardous to your data. The major heat producing power supply components are mounted to a large heat sink, external to the cabinet, by the power switch and fuse (located at the rear of the cabinet). This design is to assure that the drive components are kept as cool as possible to assure reliable data recovery.



The temperature compensation loop in a MICROPOLIS drive includes only the disk, preloaded leadscrew and spindle housing. The baseplate is specifically excluded since its expansion is compensated by a proportional change in the preload of the leadscrew.

MICROPOLIS has a reputation for getting along with most everybody. Compatibility is not a problem with MICROPOLIS. Their disk drives and/or subsystems can be easily integrated into systems such as Polymorphic, Cromemco, CCS, Ithaca Intersystems, Godbout, Northstar, Jade, Big Z, QT SBC 2/4, and many others. Many OEM manufacturers rely on MICROPOLIS to get the job done efficiently. In fact, to date they have delivered over 200,000 double track density drives; more than all of their competitors combined. Companies like Commodore, Exidy, Harris and Vector Graphic, to name just a few. Years from now, you can look back with a secure feeling knowing you made the best choice: MICROPOLIS.



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30 lbs.		77/100TPI	Yes	[illegible]
MCP10[illegible]4	1260	2	2	$1888.00
30 lbs.		154/100TPI	Yes	$1[illegible]
MCP104[illegible]2	150	1	1	$939.00
15 lbs.		77/100TPI	Yes	[illegible]
MCP104[illegible]4	630	2	1	$1107.00
15 lbs.		154/100TPI	Yes	[illegible]
MCP1041[illegible]2	315	1	1	$838.00
15 lbs.		77/100TPI	No	[illegible]
MCP1041[illegible]4	630	2	1	$1005.00
15 lbs.		154/100TPI	No	$7[illegible]

COMPLETE W/S-100 CONTROLLER, CABLES, MANUALS AND MICROPOLIS MDOS AND BASIC

ADD-ON DRIVES

MODEL / SHIP WT	CAPACITY (KBYTES)	HEADS/DRIVE. / TRACKS/DISKETTE	DRIVES/ENCLOSURE / POWER SUPPLY	LIST PRICE / OUR PRICE
MCP10[illegible]2	630	1	2	$1301.00
30 lbs.		77/100TPI	Yes	[illegible]
MCP10[illegible]4	1260	2	2	$1638.00
30 lbs.		154/100TPI	Yes	$11[illegible]
MCP10[illegible]2	315	1	1	$689.00
15 lbs.		77/100TPI	Yes	[illegible]
MCP10[illegible]4	630	2	1	$855.00
15 lbs.		154/100TPI	Yes	[illegible]
MCP1021[illegible]2	315	1	1	$586.00
		77/100TPI	No	[illegible]
MCP1021[illegible]4	630	2	1	$754.00
		154/100TPI	No	[illegible]

NOTE: Add-on modules do not include Controller, User's Manual or Diskettes.

ACCESSORIES

MCP1[illegible]-01	Regulator kit for 1041, 1021, 1015 and 1016.	[illegible]
MCP1[illegible]-01	Relocatable bootstrap kit.	[illegible]
MCP 1[illegible]	Poly 88 kit (relocated BASIC MDOS 4.0A)	[illegible]

MANUALS

MCP1[illegible]-01	User's Manual for Micropolis S-100 bus systems. Describes operation, configuring, installation of systems; explains details of our Disk Extended BASIC and DOS, and discusses diskette programming in general. 5 lbs. (included with all subsystems)	[illegible]
MCP1[illegible]-02	Maintenance Manual for all Micropolis floppy disk drives.	[illegible]

DISKETTES, ETC.

[illegible]77-10	77 Track Cert. Single Side, Box 10	[illegible]
[illegible]7-10	77 Track Cert. Double Side, Box 10	[illegible]
[illegible]	5¼" Head Cleaning Kit	[illegible]

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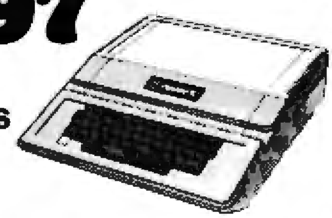
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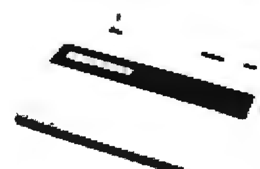
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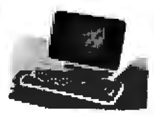
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Circle 390 on inquiry card.

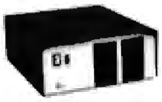
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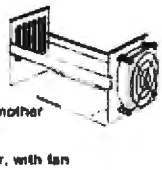
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CC+8M/F 130
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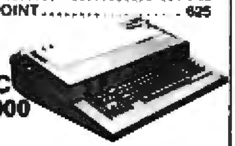
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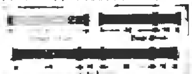
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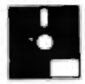
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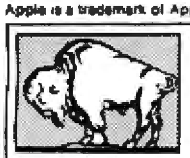
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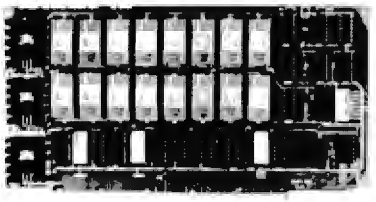
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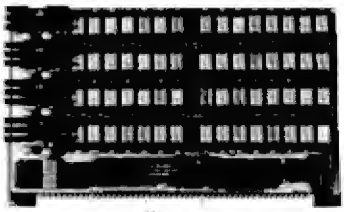
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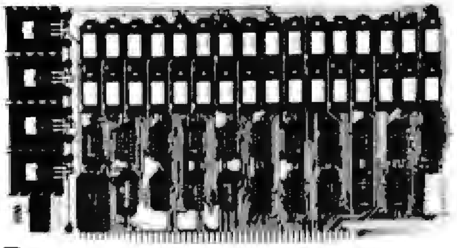
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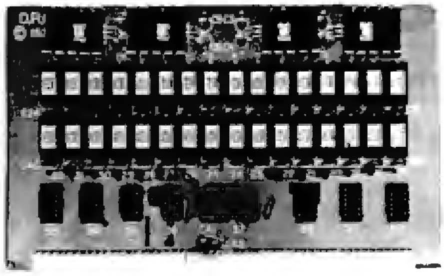
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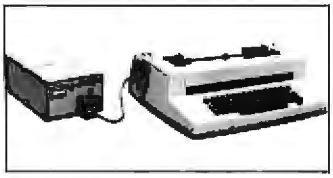
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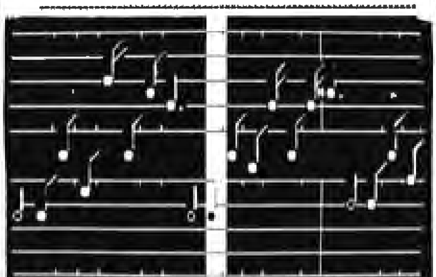
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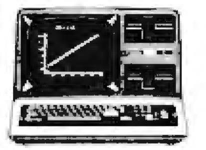
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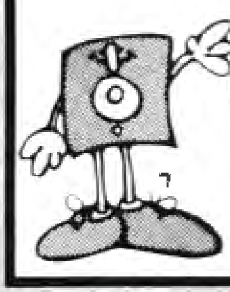
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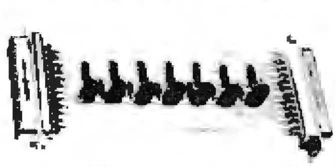
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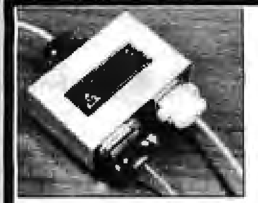
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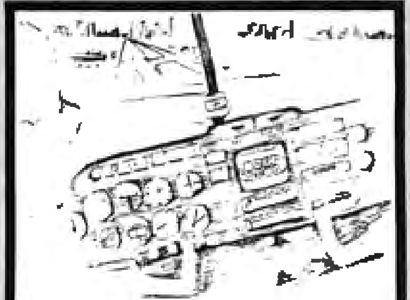
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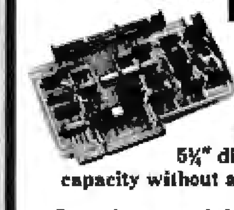
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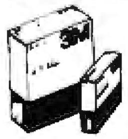
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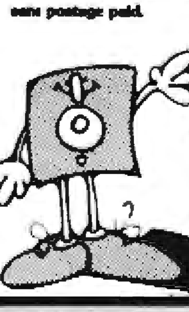
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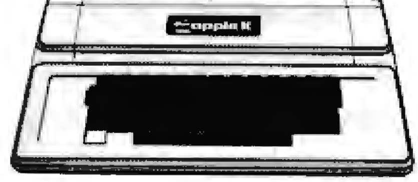
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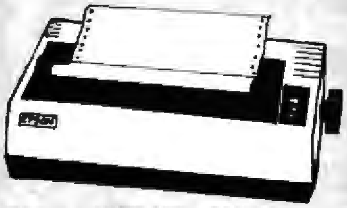
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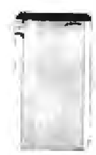
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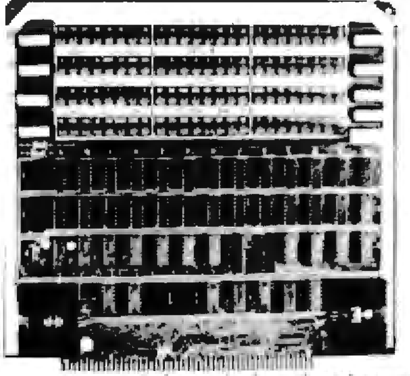
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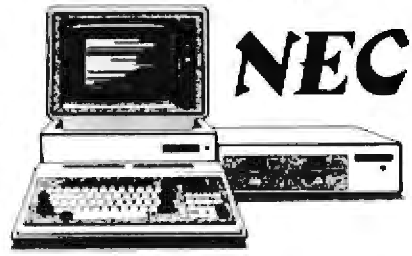
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TSX-200K	*Kit*	$119.95
TSX-200A	*A&T*	$149.95



4 MHz Z-80 CPU, 80 x 25 display with graphics and 8 colors, 32K RAM, 24K ROM, parallel serial cassette interfaces, upper lower case, numeric keypad, 10 special function keys, uses CP M 2.2

NEC-8001A	*32K CPU keyboard*	$1095.00
NEC-8012A	*I O with 32K RAM*	$695.00
NEC-8031A	*Dual disk unit*	$1095.00
VDM-651200	*12" green CRT*	$269.95
NEC-1202D	*Hi-res RGB color CRT*	$1045.00
VDC-651212	*12" color monitor*	$479.95
NEC-9010S	*CP·M 2.2 for NEC*	$150.00
NEC-90005	*Gen. accting softwr*	$375.00

Intersell

Sellum I

NEC Spinwriter w/ Intelligent Controller



Standard serial, Centronics parallel, and current loop interfaces • Selectable baud rates 50 to 19,200 • Automatic bidirectional printing • Logic seeking • 650 character buffer with optional 16K buffer • 55 characters per second print speed • Comes with vertical forms tractor, ribbon, thimble and cable • Diablo compatible software • Available with or without optional front panel

PRD-55511	*1K no front panel*	$2795.00
PRD-55512	*16K no front panel*	$2895.00
PRD-55515	*1K w front panel*	$2995.00
PRD-55516	*16K w front panel*	$3095.00

Intersell NEC 3500Q

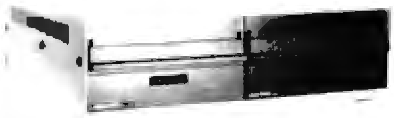
Intersell has announced that, available in September, they will offer a version of the new NEC Model 3500Q Spinwriter (30 cps) that will bring to the customer the same standard features as the Sellum I (except the tractor assembly which is optional on the 3500Q) but incorporating the added features of the NEC Model 3500Q

PRD-55351	*3500Q 1K*	$1995.00
PRD-55352	*3500Q 16K*	$2095.00
PRA-55100	*Deluxe tractor option*	$300.00

JADE

Disk Sub-Systems

Shugart, Siemens, Qume



Handsome metal cabinet with proportionally balanced air flow system • Rugged dual drive power supply • Power cable kit • Power switch, line cord, fuse holder, cooling fan • Never-Mar rubber feet • All necessary hardware to mount 2-8" disk drives, power supply, and fan • Does not include signal cable

Dual 8" Subassembly Cabinet

END-000420	*Bare cabinet*	$59.95
END-000421	*Cabinet kit*	$225.00
END-000431	*A & T*	$359.95

8" Disk Drive Subsystems
Single Sided, Double Density

END-000423	*Kit w 2 FD100 8Ds*	$924.95
END-000424	*A & T w 2 FD100 8Ds*	$1124.95
END-000433	*Kit w 2 SA-801Rs*	$999.95
END-000434	*A & T w 2 SA-801Rs*	$1195.00

8" Disk Drive Subsystems
Double Sided, Double Density

END-000426	*Kit w 2 DT-8s*	$1224.95
END-000427	*A & T w 2 DT-8s*	$1424.95
END-000436	*Kit w 2 SA-851Rs*	$1465.00
END-000437	*A & T w 2 SA-851Rs*	$1695.00



QUME DT-8

8" Double-Sided, Double-Density Disk Drive

1 Drive	**$524.95 each**
2 Drives	**$499.95 each**
10 Drives	**$479.95 each**

Jade Part Number MSF-750080

SIEMENS 8"

8" Single-Sided, Double-Density Disk Drive

1 Drive	**$384.95 each**
2 Drives	**$349.95 each**
10 Drives	**$324.95 each**

Jade Part Number MSF-201120

Shugart 801R

8" Single-Sided, Double-Density Disk Drive

1 Drive	**$394.95 each**
2 Drives	**$389.95 each**

Jade Part Number MSF-10801R

MPI B-51

5¼" Single-Sided, Double-Density Disk Drive

1 Drive	**$234.95 each**
2 Drives	**$224.95 each**
10 Drives	**$219.95 each**

Jade Part Number MSM-155100

END-000213	*Case & power supply*	$74.95

Micro-Sci

Apple Disk Drives

Increased Capacity - Decreased Price

40 or 70 track drives • operates with DOS 3.2 and 3.3, Language System, and the Z80 Softcard • 40 and 70 track drives may be mixed on your Apple II • With two 40 track drives you get a 12.5% increase in capacity, 300% improvement in track-to-track access, and save about 15% • With two 70 track drives instead of four 35 track drives you get the same capacity, 300% improvement in track-to-track access time, and save about 45%.

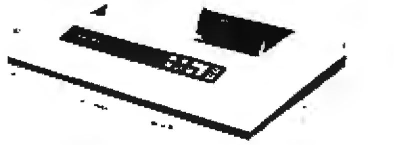
IOD-2340A	*A-40 with cable*	$399.95
IOD-2370A	*A-70 with cable*	$529.95
IOD-2300A	*Micro-sci controller*	$89.95

Circle 188 on inquiry card.

Grand Opening Sale

★★★★★★ *San Diego* ★★★★★★ *Hawthorne* ★★★★★★ *Woodland Hills* ★★★★★★

Printers



Dual-Mode 200 - Malibu

200 CPS/9 x 9 matrix or 70 CPS/19 x 18 matrix for letter quality, stores up to 12 different fonts, hi-res dot graphics, single sheet and tractor feed, RS-232C and parallel interfaces

PRM-35200 *Dual-Mode 200* **$2695.00**



BEST BUY in PRINTERS - Epson

MX-70 132 column, 80 CPS, 5 x 7 dot matrix, adjustable tractor feed, & graphics

PRM-27070 *List $459* **$399.95**

MX-80 132 column, 80 CPS, bi-directional/logic seeking printing, 9 x 9 dot matrix, adjustable tractor feed, & 64 graphics characters

PRM-27080 *List $645* **$474.95**

MX-80FT same as MX-80 with friction feed

PRM-27082 *List $745* **$574.95**

MX-100 233 column, correspondence quality, ultra-high resolution graphics, up to 15" paper, friction feed & removable adjustable tractor feed, 18 x18 dot matrix, 80 CPS, programmable forms handling

PRM-27100 *List $945* **$795.00**

PRA-27084 *Serial interface* **$69.95**
PRA-27088 *Serial intf & 2K buffer* **$144.95**
PRA-27081 *Apple card* **$74.95**
PRA-27082 *Apple cable* **$22.95**
PRA-27086 *IEEE 488 card* **$52.95**
PRA-27087 *TRS-80 cable* **$32.95**
PRA-27085 *Graftrax II* **$95.00**
PRA-27083 *Extra ribbon* **$14.95**

Accessories for TRS-80

DISK DRIVES for TRS-80

27% more storage, 8 times faster, 40 track with free patch, 120 day warranty.

MSM-12410C *Save $125.00 !!!* **$325.00**

8" DISK DRIVES for MODEL II

2 double density drives with cabinet, power supply, & cables

END-000433 *Kit* **$1050.00**
END-000434 *Assembled* **$1250.00**
WCA-5036A *Cable (required)* **$29.95**

16K Atari ... $359.95

ATARI 800 - Atari

Complete personal computer with high resolution color graphics, built-in RF modulator, 4 controller ports, internal speaker, 16K RAM & 8K ROM

SYO-2080A *16K Atari 800* **$759.95**
Atari 800 with 32K of RAM **$799.95**
Atari 800 with 48K of RAM **$849.95**
SYO-2040A *16K Atari 400* **$359.95**
MSM-330810 *Disk drive* **$595.00**
MSM-330815 *Dual drive* **$1395.00**
IOX-5050A *850 interface* **$199.95**
MEX-16853K *16K RAM module* **$69.95**
SFI-241011005 *Visicalc* **$184.95**

Accessories for Apple



16K MEMORY UPGRADE

Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.

MEX-16100K *TRS-80 kit* **$25.00**
MEX-16101K *Apple kit* **$25.00**
MEX-16102K *Exidy kit* **$25.00**

16K RAM Card - Microsoft

(There is life after 48K)

MEX-16300A *A & T* **$174.95**

Z-80* CARD for APPLE

Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80 CPU card, CP/M 2.2, & BASIC-80*

CPX-30800A *A & T* **$299.95**

APPLE CLOCK - Cal Comp Sys

Real time clock w/ battery back-up

IOK-2030A *A & T* **$109.95**

8" DISK CONTROLLER

New from Vista Computer, single or double sided, single or double density, compatible with DOS 3.2/3.3, Pascal, & CPM 2.2, Shugart & Qume compatible

IOD-2700A *A & T* **$499.95**

8" DRIVES for APPLE

Controller, DOS, two 8" double density drives, cabinet, power supply, & cables

Special Package Price *Kit* **$1399.95**

PRINTER INTERFACE - C.C.S.

Centronics type I/O card w/ firmware

IOI-2041A *A & T* **$99.95**

AIO, ASIO, APIO - S.S.M.

Parallel & serial interface for your Apple (see Byte pg 11)

IOI-2050K *Par & Ser kit* **$139.95**
IOI-2050A *Par & Ser A & T* **$169.95**
IOI-2052K *Serial kit* **$89.95**
IOI-2052A *Serial A & T* **$99.95**
IOI-2054K *Parallel kit* **$69.95**
IOI-2054A *Parallel A & T* **$89.95**

A488 - S.S.M.

IEEE 488 controller, uses simple basic commands, includes firmware and cable, 1 year guarantee, (see April Byte pg 11)

IOX-7488A *A & T* **$399.95**

CPS MULTICARD - Mtn. Computer

Three cards in one! Real time clock/calendar, serial interface, & parallel interface all on one card.

IOX-2300A *A & T* **$199.95**

Apple-CAT - Novation

Software selectable 1200 or 300 baud, direct connect, auto-answer/auto-dial, auxiliary 3-wire RS232C serial port for printer.

IOM-5232A *Save $50.00!!!* **$325.00**

Single Board Computers



AIM-65 - Rockwell

6502 computer with alphanumeric display, printer, & keyboard, and complete instructional manuals

CPK-50165 *1K AIM* **$424.95**
CPK-50465 *4K AIM* **$499.95**
SFK-74600008E *8K BASIC ROM* . **$99.95**
SFK-64600004E *4K assembler ROM* **$84.95**
PSX-030A *Power supply* **$64.95**
ENX-000002 *Enclosure* **$54.95**

4K AIM, 8K BASIC, power supply, & enclosure

Special package price **$675.00**

Z-80* STARTER KIT - SD Systems

Complete Z-80 computer with RAM, ROM, I/O, display, keyboard, manual, and kluge area.*

CPS-30010K *Kit* **$369.95**
CPS-30010A *A & T* **$459.95**

SYM-1 - Synertek Systems

Single board computer with 1K of RAM, 4K of ROM, key-pad, LED display, 20ma & cassette interface on board.

CPK-50020A *A & T* **$249.95**

Video Terminals

VIEWPIONT - ADDS

Detachable keyboard, serial RS232C interface, baud rates from 110 to 19,200, auxiliary serial output port, 24 x 80 display, tiltable screen, international character set

VDT-501210 *Sale Priced* .. **$639.95**

TELEVIDEO 950

Detachable keyboard, split screen with line lock, etched CRT, programmable function keys, on-screen status line, buffered auxiliary port, 14 x 10 dot matrix, self test, serviced nationwide by General Electric

VDT-901250 *List $1195.00* . **$995.00**

Video Monitors

Leedex / Amdek

Reasonably priced video monitors

VDM-801210 *Video 100 12" B&W* .. **$139.95**
VDM-801230 *Video 100-80 12" B& W* **$179.95**
VDM-801250 *12" Green Phospor* **$169.95**
VDC-801310 *13" Color I* **$379.95**

12" COLOR MONITOR - NEC

Hi-res monitor with audio & sculptured case

VDC-651212 *Color Monitor* **$479.95**

12" GREEN SCREEN - NEC

20 MHz, P31 phosphor video monitor with audio, exceptionally high resolution - A fantastic monitor at a very reasonable price

VDM-651200 *12" monitor* **$269.95**

EPROM Erasers

EPROM ERASERS

L.S. Engineering UV eraser for up to 48 EPROMs

XME-3200 *A & T* **$39.99**

Spectronics hi intensity industrial eraser

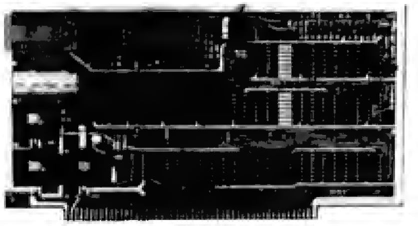
XME-3100 *Without timer* **$69.50**
XME-3101 *With timer* **$94.50**

Grand Opening Sale

Circle 187 on inquiry card.

★★★★★★ *San Diego* ★★★★★★ *Hawthorne* ★★★★★★ *Woodland Hills* ★★★★★★

S-100 PROM Boards



PB-1 - S.S.M.
2708, 2716 EPROM board with built-in programmer

MEM-99510K	*Kit*	$154.95
MEM-99510A	*A & T*	$219.95

PROM-100 - SD Systems
2708, 2716, 2732, 2758, & 2516 EPROM programmer

MEM-99520K	*Kit*	$219.95
MEM-99520A	*Jade A & T*	$269.95

EPROM BOARD - Jade
16K or 32K uses 2708's or 2716's, 1K boundary

MEM-16230K	*Kit*	$79.95
MEM-16230A	*A & T*	$119.95

S-100 Video

VB-3 - S.S.M.
80 characters x 24 lines expandable to 80 x 48 for a full page of text, upper & lower case, 256 user defined symbols, 160 x 192 graphics matrix, memory mapped, has key board input.

IOV-1095K	*4 MHz kit*	$349.95
IOV-1095A	*4 MHz A & T*	$439.95
IOV-1096K	*80 x 48 upgrade*	$39.95

VDB-8024 - SD Systems
80 x 24 I/O mapped video board with keyboard I/O, and on-board Z-80A.*

IOV-1020K	*Kit*	$399.95
IOV-1020A	*Jade A & T*	$459.95

VIDEO BOARD - S.S.M.
64 characters x 16 lines, 128 x 48 matrix for graphics, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.

IOV-1051K	*Kit*	$149.95
IOV-1051A	*A & T*	$219.95
IOV-1051B	*Bare board*	$34.95

Motherboards

ISO-BUS - Jade
Silent, simple, and on sale - a better motherboard

6 Slot (5¼" x 8½")		
MBS-061B	*Bare board*	$19.95
MBS-061K	*Kit*	$39.95
MBS-061A	*A & T*	$49.95
12 Slot (9¾" x 8½")		
MBS-121B	*Bare board*	$29.95
MBS-121K	*Kit*	$69.95
MBS-121A	*A & T*	$89.95
18 Slot (14½" x 8½")		
MBS-181B	*Bare board*	$49.95
MBS-181K	*Kit*	$99.95
MBS-181A	*A & T*	$139.95

Mainframes

MAINFRAME - Cal Comp Sys
12 slot S-100 mainframe with 20 amp power supply

ENC-112105	*Kit*	$329.95
ENC-112106	*A & T*	$399.95

DISK MAINFRAME - N.P.C.
Holds 2 8" drives and a 12 slot S-100 system. Attractive metal cabinet with 12 slot motherboard & card cage, power supply, dual fans, lighted switch, and other professional features

ENS-112325	*with 25 amp p.s.*	$699.95

S-100 Memory

MEMORY BANK - Jade
4 MHz, IEEE S-100, bank selectable, 8 or 16 bit, expandable from 16K to 64K

MEM-99730B	*Bare board*	$49.95
MEM-99730K	*Kit, no RAM*	$199.95
MEM-16730K	*16K kit*	$219.95
MEM-32731K	*32K kit*	$239.95
MEM-48732K	*48K kit*	$259.95
MEM-64733K	*64K kit*	$279.95
Assembled & tested		add $50.00

EXPANDORAM II - S D Systems
4 MHz RAM board expandable from 16K to 64K

MEM-16630K	*16K kit*	$275.95
MEM-32631K	*32K kit*	$295.95
MEM-48632K	*48K kit*	$315.95
MEM-64633K	*64K kit*	$335.95
Assembled & tested		add $50.00

64K RAM - Calif Computer Sys
4 MHz bank port / bank byte selectable, extended addressing, 16K bank selectable, PHANTOM line allows memory overlay, 8080 / Z-80 / front panel compatible.

MEM-64565A	*A & T*	$575.00

64K STATIC RAM - Mem. Merch.
64K static S-100 RAM card, 4-16K banks, up to 8 MHz

MEM—64400A	*A & T*	$625.00

32K STATIC RAM - Jade
2 or 4 MHz expandable static RAM board uses 2114L's

MEM-16151K	*16K 4 MHz kit*	$169.95
MEM-32151K	*32K 4 MHz kit*	$299.95
Assembled & tested		add $50.00

16K STATIC RAM - Mem Merchant
4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks, "disable-able" in 1K segments, extended addressing, low power

MEM-16171A	*A & T*	$174.95

S-100 Disk Controller

DOUBLE-D - Jade
Double density controller with the inside track, on-board Z-80A, printer port, IEEE S-100, can function on an interrupt driven buss*

IOD-1200K	*Kit*	$299.95
IOD-1200A	*A & T*	$375.00
IOD-1200B	*Bare board*	$59.95

VERSAFLOPPY II - SD Systems
New double density controller for both 8" & 5¼"

IOD-1160K	*Kit*	$339.95
IOD-1160A	*A & T*	$379.95

DOUBLE DENSITY - Cal Comp Sys
5¼" and 8" disk controller, single or double density, with on-board boot loader ROM, and free CP/M 2.2 and manual set.*

IOD-1300A	*A & T*	$369.95

S-100 I/O

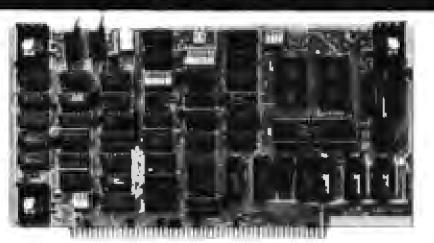
S.P.I.C. - Jade
Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO

IOI-1045K	*2 CTC's, 1 SIO, 1 PIO*	$179.95
IOI-1045A	*A & T*	$239.95
IOI-1046K	*4 CTC's, 2 SIO's, 1 PIO*	$219.95
IOI-1046A	*A & T*	$299.95
IOI-1045B	*Bare board w/ manual*	$49.95

I/O-4 - S.S.M.
2 serial I/O ports plus 2 parallel I/O ports

IOI-1010K	*Kit*	$179.95
IOI-1010A	*A & T*	$249.95
IOI-1010B	*Bare board*	$35.00

S-100 CPU



CB-2 Z-80 CPU - S.S.M.
2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.

CPU-30300K	*Kit*	$239.95
CPU-30300A	*A & T*	$299.95

2810 Z-80* CPU - Cal Comp Sys
2/4 MHz Z-80A CPU with RS-232C serial I/O port and on-board MOSS 2.2 monitor PROM, front panel compatible.*

CPU-30400A	*A & T*	$269.95

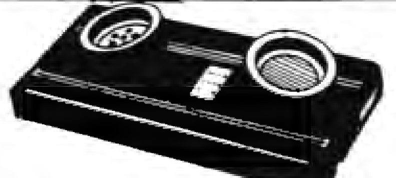
SBC-200 - SD Systems
4 MHz Z-80 CPU with serial & parallel I/O ports, up to 8K of on-board PROM, software programmable baud rate generator, 1K of on-board RAM, Z-80 CTC.*

CPC-30200K	*Kit*	$339.95
CPC-30200A	*Jade A & T*	$399.95

THE BIG Z* - Jade
2 or 4 MHz switchable Z-80 CPU with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600*

CPU-30201K	*Kit*	$139.95
CPU-30201A	*A & T*	$189.95
CPU-30200B	*Bare board*	$35.00

Novation Cat Modem



IOM-5200A	*List price $189.95*	$125.00

D-CAT 300 baud, direct connect modem

IOM-5201A	*Special sale price*	$169.95

AUTO-CAT Auto answer/originate, direct connect

IOM-5230A	*Special sale price*	$239.95

SMARTMODEM - Hayes
Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable

IOM-5400A	*Smartmodem*	$269.95

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Continental U.S. 800-421-5500

Inside California 800-262-1710

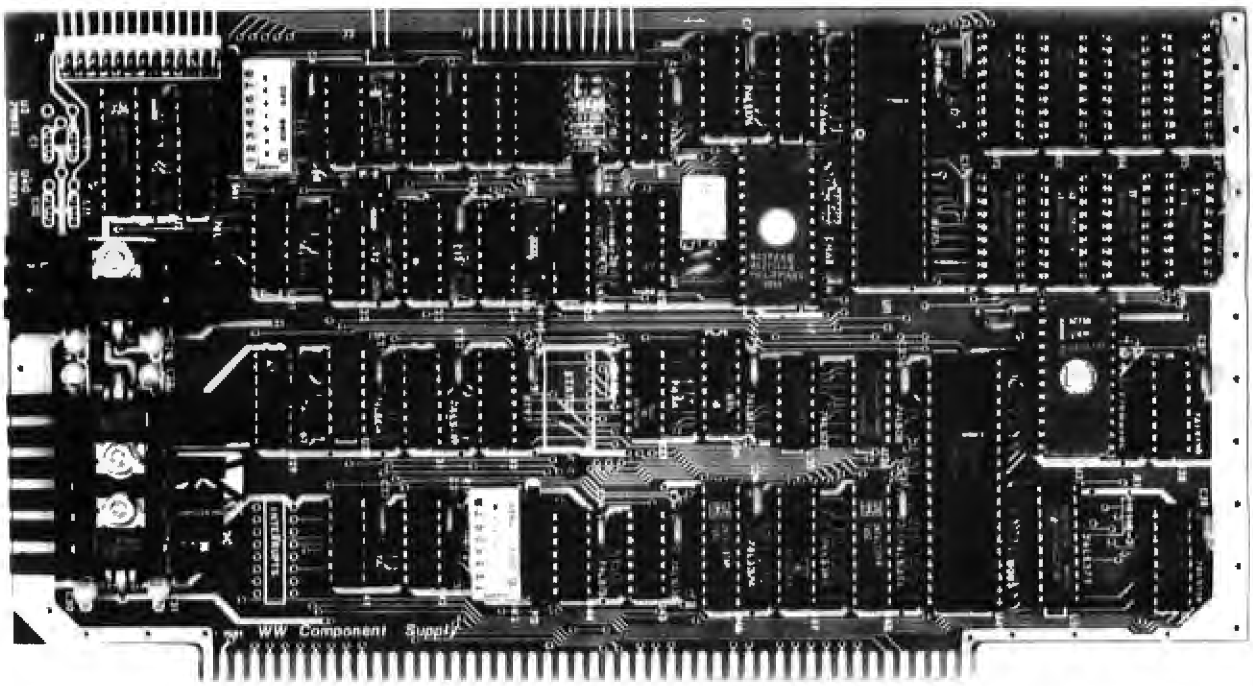
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INTELLIGENT VIDEO I/O FOR S-100 BUS



VIO-X

The VIO-X Video I/O Interface for the S-100 bus provides features equal to most intelligent terminals both efficiently and economically. It allows the use of standard keyboards and CRT monitors in conjunction with existing hardware and software. It will operate with no additional overhead in S-100 systems regardless of processor or system speed.

Through the use of the Intel 8275 CRT controller with an onboard 8085 processor and 4k memory, the VIO-X interface operates independently of the host system and communicates via two ports, thus eliminating the need for host memory space. The screen display rate is effectively 80,000 baud.

The VIO-X1 provides an 80 character by 25 line format (24 lines plus status line) using a 5 × 7 character set in a 7 × 10 dot matrix to display the full upper and lower case ASCII alphanumeric 96 printable character set (including true descenders) with 32 special characters for escape and control characters. An optional 2732 character generator is available which allows an alternate 7 × 10 contiguous graphics character set.

The VIO-X2 also offers an 80 character by 25 line format but uses a 7 × 7 character set in a 9 × 10 dot matrix allowing high-resolution characters to be used. This model also includes expanded firmware for block mode editing and light pen location. Contiguous graphics characters are not supported.

Both models support a full set of control characters and escape sequences, including controls for video attributes, cursor location and positioning, cursor toggle, and scroll speed. An onboard Real Time Clock (RTC) is displayed in the status line and may be read or set from the host system. A checksum test is performed on power-up on the firmware EPROM.

Video attributes provided by the 8275 in the VIO-X include:

- FLASH CHARACTER
- INVERSE CHARACTER
- UNDERLINE CHARACTER or
- ALT. CHARACTER SET
- DIM CHARACTER

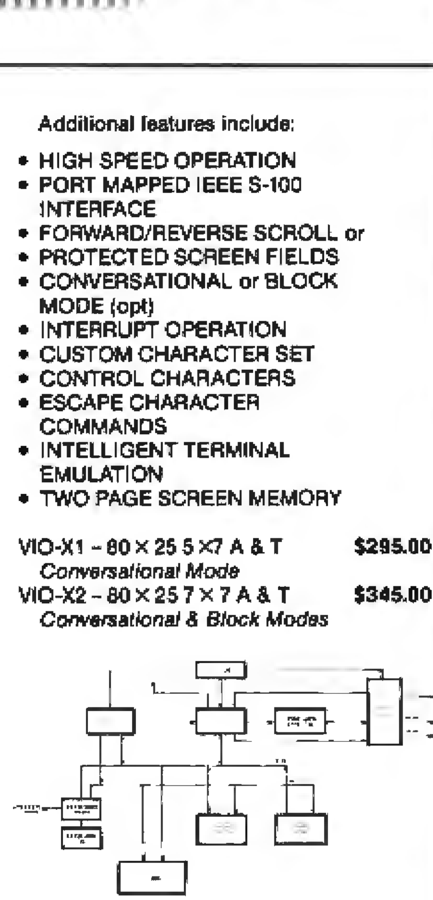
The above functions may be toggled together or separately.

The board may be addressed at any port pair in the IEEE 696 (S-100) host system. Status and data ports may be swapped if necessary. Inputs are provided for parallel keyboard and for light pen as well as an output for audio signalling. The interrupt structure is completely compatible with Digital Research's MP/M ®.

Additional features include:

- HIGH SPEED OPERATION
- PORT MAPPED IEEE S-100 INTERFACE
- FORWARD/REVERSE SCROLL or
- PROTECTED SCREEN FIELDS
- CONVERSATIONAL or BLOCK MODE (opt)
- INTERRUPT OPERATION
- CUSTOM CHARACTER SET
- CONTROL CHARACTERS
- ESCAPE CHARACTER COMMANDS
- INTELLIGENT TERMINAL EMULATION
- TWO PAGE SCREEN MEMORY

VIO-X1 – 80 × 25 5 ×7 A & T *Conversational Mode*	$295.00
VIO-X2 – 80 × 25 7 × 7 A & T *Conversational & Block Modes*	$345.00



VIO-X S-100 I/O INTERFACE

FULCRUM™ COMPUTER PRODUCTS

Distributed by:
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Circle 395 on inquiry card.

California Digital

Post Office Box 3097 B • Torrance, California 90503



CONTROL DATA
CL416 MATRIX PRINTER
$1395

In a dark corner of a Control Data warehouse our scouts have recently located a small quantity of brand new, vintage 1978, Control Data CL-416 matrix printers. The CL-416 was designed for extra heavy duty industrial applications. Please do not confuse this work horse printer with the new low cost imports.
The unit prints a full 96 character ASCII set at a conservative 175 characters / second. One kilobyte buffer accepts RS232 signals upto 9600 baud. Vertical forms control unit provides added flexibility for business applications. The CL-416 has a split primary power transformer to allow field voltages between 115 and 230 volts.
Original cost of the printer is estimated at $5,000. California Digital blow out price is only $1,395. Shipped via motor freight in factory sealed containers. SPC-CL416

World's Best Selling Printer

EPSON MX80

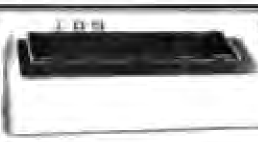


Immediate Delivery

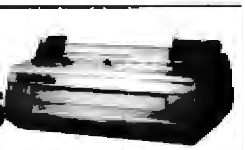
Only $475

Correspondence quality printing.
A lot of printers costing a lot more can't match the MX-80 performance. It gives you a choice of 40, 80, 66 or 132 columns of printing in as many as four distinct printing density modes, a total of twelve different combinations which can accommodate nearly any printing requirement.
... directional printing. Logical ... of shortest lines ... CPS. 64 graphics characters. Forms handling. The list of standard features goes on and on. The fact is that there are few printers that can ... with the MX-80 at ANY price. And now — ZERO ... in its extremely affordable price range.

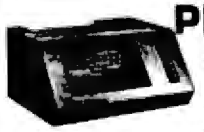
ABCDEFGHIJ ...



Paper Tiger
560G
$1395



NEC Spinwriter
5510P/S
$2795



PRINTRONIX
P-300 $4500
P-600 $6150

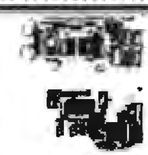


IBM 3101
Display Terminal
IBM Direct Price $1295
California Digital discount price $1195



AMPEX
DIALOGUE 80
CRT TERMINAL
$995

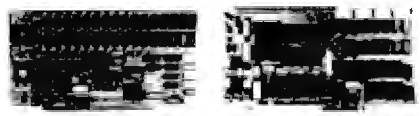
ACCESSORIES FOR THE APPLE COMPUTER



MICROSOFT PRODUCTS
Apple to Z-80 CPU card
D.C. HAYES PRODUCTS
Micromodem for Apple
COMPUTER STOP PRODUCTS
Double Vision / 80 Column Video
INTERACTIVE STRUCTURES
16 Channel A/D card AI02

APPLE BRAND PRODUCTS
Apple Language card
Floppy disk with controller
Floppy disk without controller
Apple parallel interface
SSM MICROCOMPUTER
Dual serial parallel interface AIO

S-100 BOARDS
Assembled • Tested • Burned-in



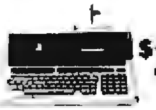
PRINTERS

Epson MX80	PRAMX80	1475
Epson MX80FT	PRKMX80F	595
Epson MX100	PREMX100	925
Anadex 9500	PRA9500	1395
Anadex 9501	PRA9501	1395
Anacom 150	PRA150	1075
IDS Paper Tgr.	PRG460G	1095
IDS Tiger 560	PRG560G	1350
Diablo 630	PRD630	2130
Diablo 1650	PRD1650	2850
Diablo 1640	PRD1640	2436
Datasouth 180	PRD180	1350
Printronix 300	PRP300	4500
Printronix 600	PRP600	6150
NEC/Selium 1	PRN5510pa	2895
NEC/Sm 10K	PRN3510pa	2795
TEC/Starwrit.	PRY300	1396
Okidata 80	PRO80	410
Okidata 82	PRO82	610
Okidata 83	PRO83	995
Teletype 43K	PTT4320K	1085
Texas Ins. 810	PRT810B	1450
Tex. Ins 810C	PRT810C	1795
Centronics 730	PRC730P	520
Centronics 737	PRC737P	495
Centronics 739	PRC739P	[illegible]
Centronics 704-9	PRC704-9	
Centronics 704-11	PRC704-11	

SYSTEMS



APPLE II $1150
48K MEMORY



$2550 HEWLETT PACKARD HP85

Hew/Pack 85	SYSHP85	2550
Hew/Pack 83	SYSHP83	1895
Altos AC28000	SYSAC28000	4795
Osborne 1	SYSOSB1	1795
Commodore	SYSC8032	1495
Commodore	SYSC8096	1795
Superbrain64Q	SYSSB64Q	3350
Superbrain64D	SYSSB64D	2850
Northstar 64Q	SYSN64Q	3295
Northstar 64D	SYSN64D	2895
NEC/PC8000	SYSPC8000	call
Apple II Plus	SYSAP	1170

VIDEO TERMINALS

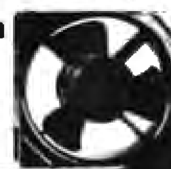
ADDS Viewpoint	VDT-RVP	595
ADDS Regent 25 numeric cluster	VDT-R25	850
ADDS Regent 30 25th status line	VDT-R30	950
ADDS Regent 40 limited graphic	VDT-R40	1195
ADDS Regent 60 Block mode	VDT-R60	1495
Ampex Dialogue 80 two page, detatch	VDT-D80	995
Digital Equipment VT-100	VDT-V100	1595
Digital Equipment VT-132	VDT-V132	1895
Direct VP-800A emulator	VDT-P800	call
Hazeltine 1410	VDT-H1410	750
Hazeltine 1420	VDT-H1420	795
Hazeltine 1500	VDT-H1500	
Hazeltine 1510	VDT-H1510	
Hazeltine 1520	VDT-H1520	
Hewlett Packard 2621A	VDT-HP21A	
Hewlett Packard 2621P	VDT-HP21P	
IBM 3101-10 character mode green	VDT-3101	1195
IBM 3101-20 block mode	VDT-31012	1395
Lear Seigler 3A upper case only	VDT-L3A	850
Lear Seigler ADM5	VDT-L5	845
Lear Seigler ADM31	VDT-L31	1385
Lear Seigler ADM42	VDT-L42	1095
Visual 200	VDT-V200	995
Televideo 910C (new)	VDT-T910	595
Televideo 912C	VDT-T912	665
Televideo 920C	VDT-T920	745
Televideo 950C detatchable keybd.	VDT-T950	985
Zenith Z-19	VDT-Z-19	735

VIDEO MONITORS



P-31 grn phosphor	$259
Leedex/Amdek 12"100	129
Leedex 100 green	169
Leedex 100-80	197
color I	389
color	378
green	219
Panasonic color 10	
	149
Sanyo 12" green phos.	235
Sanyo 15" BW	259
Sanyo 13" color	[illegible]

Rotron Muffin Fan



$14.77 | $12.00 100 | 10.50 1000

115 VAC. 7 Watts WR2A1
Factory fresh Muffin fans
NOT pull-outs. EMF-4M

VISA
master charge

All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $2.00; each additional add $.40
Foreign orders 10% shipping. Excess will be refunded.
California residents add 6% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "Strong Dun & Bradstreet."
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

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Circle 55 on inquiry card.

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PLASTIC LIBRARY CASE SUPPLIED WITH PURCHASE OF EVERY TEN DISKETTES



MEMOREX FLEXIBLE DISKETTES

$1.99

Quantity One Hundred

INVENTORY REDUCTION SALE!

California Digital has recently purchased over 200,000 Memorex Diskettes. Frankly we have over committed and must liquidate our excess inventory. This is your chance to take advantage of this special buying opportunity. All diskettes sold by California Digital include a free library case ($5.00 value.) Offer expires November 30, 1981. Shipping: 5¼" Mini-Diskette add $6.00 per hundred. Eight inch add $12.00 per hundred. Calif. residents add 6%

Part Number	Description	Quantity	List Price	Prepaid One Hundred	Credit Card Net 30	Less Than One Hundred	Extension
3401	Five Inch for Apple, TRS80, PET, Atari		$4.50	$1.99	2.15	2.49	
3403	Five Inch Ten Sector for Horizon, Zenith/Heath		4.50	1.99	2.15	2.49	
3405	Five Inch Sixteen Sector Vector Graphics		4.50	1.99	2.15	2.49	
3431	Five Inch Soft Sector with Reinforced Hub Ring		4.65	2.19	2.35	2.69	
3060	Eight Inch Single Side Diablo, IBM 3740		5.00	2.19	2.35	2.69	
3090	Eight Inch Double Density Radio Shack Model II		6.50	2.95	3.19	3.49	
3114	Eight Inch Double Side Double Density		7.00	3.49	3.75	4.95	

Individual ______ Company ______ Sub Total ______

Address ______ Phone ______ Tax ______

City ______ State ______ Zip ______ Shipping ______

Card No. ______ Exp. ______ Computer ______ Total ______

VISA

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California Digital

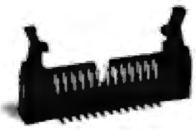
Order Toll Free!

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(213) 679-9001

Circle 58 on inquiry card. **4738 - 156th Street • Lawndale, Calif. 90260**

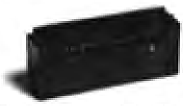
IDC CONNECTORS



RIGHT ANGLE HEADERS

	SOLDER TAIL		WIRE WRAP	
Size	Part No.	Price	Part No.	Price
10	IDH10SRB	$1.20	IDH10WRB	$2.60
20	IDH20SRB	1.90	IDH20WRB	4.15
26	IDH26SRB	2.75	IDH26WRB	5.35
34	IDH34SRB	3.75	IDH34WRB	6.25
40	IDH40SRB	3.75	IDH40WRB	7.35
50	IDH50SRB	4.75	IDH50WRB	9.20

1" Spacing. Mounts on PC Board & Mates with IDS Socket below. Ejector Bars - 4/1.00.



EDGE CARD CONNECTORS

Size	Part No.	Price
10	IDE10B	$3.95
20	IDE20B	4.35
26	IDE26B	5.00
34	IDE34B	6.05
40	IDE40B	6.90
50	IDE50B	7.50

.1" Spacing. Crimps onto cable with ordinary vise & mates with standard .062" Card Edge.



RIBBON CABLE

	Solid Color		Color Coded	
Size	10 ft.	100 ft.	10 ft.	100 ft.
10	2.90	17.00	4.00	30.00
14	3.40	23.80	5.00	42.00
16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
34	6.80	57.80	11.00	102.00
40	7.80	68.00	13.00	120.00
50	9.50	85.00	16.00	150.00



25 PIN "D" CONNECTORS

Solder Style	Part No.	Price
Male	DB25P	$2.95
Female	DB25S	3.95
Cover	DB25C	1.50
IDC Style		
Male	IDB25P	6.25
Female	IDB25S	6.60
Cover	IDB25C	1.60

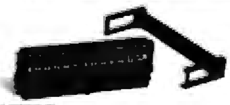
Solder Style solders onto cable. IDC Style crimps onto cable with vise. 9, 15, 37 and 50 pin available also.



CABLE PLUGS

Size	Part No.	Price
14	IDP14B	$1.45
16	IDP16B	1.65
24	IDP24B	2.50
40	IDP40B	4.15

.1" Spacing Crimps onto cable with ordinary vise & plugs into standard IC Socket.



SOCKETS

Size	Part No.	Price
10	IDS10B	$1.88
20	IDS20B	2.75
26	IDS26B	3.50
34	IDS34B	4.50
40	IDS40B	5.40
50	IDS50B	6.50

.1" Spacing. Crimps onto cable with ordinary vise & mounts to header sold above.

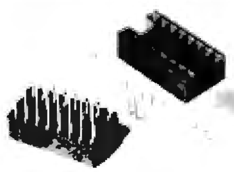
WIRE WRAP SUPPLIES

WIRE WRAP WIRE

#30 Wire Wrap Wire

Length	100/Bag	500/Bag	1K/Bag
2.5"	$1.38	$3.94	$6.81
3.0"	1.43	4.25	7.46
3.5"	1.51	4.57	8.11
4.0"	1.56	4.88	8.73
4.5"	1.63	5.21	9.39
5.0"	1.69	5.54	10.04
5.5"	1.74	5.92	10.69
6.0"	1.82	6.23	11.34
6.5"	2.11	7.06	12.99
7.0"	2.19	7.44	13.68
7.5"	2.29	7.78	14.40
8.0"	2.35	8.12	15.10
8.5"	2.40	8.46	15.80
9.0"	2.46	8.92	16.51
9.5"	2.53	9.15	17.22
10.0"	2.63	9.58	17.91

All lengths are overall, including 1" strip on each end. Choose from colors; Red, Blue, Black, Yellow, White, Green, Orange, and Violet.



Size	Part No.	Each	Tube
08	ICN083WBSG	.44	52x .39 = $20.28
14	ICN143WBSG	.53	30x .46 = $13.80
16	ICN163WBSG	.58	26x .50 = $13.00
18	ICN183WBSG	.78	23x .68 = $15.64
20	ICN203WBSG	1.00	21x .85 = $17.85
22	ICN224WBSG	1.07	19x .92 = $17.48
24	ICN246WBSG	1.09	17x1.09 = $15.98
28	ICN286WBSG	1.43	15x1.23 = $18.45
40	ICN406WBSG	1.85	10x1.60 = $16.00

Selective Plating provides gold in contact where it counts. 3-level wrap. Save by buying sockets by the tube. All gold available at ½e/pin extra charge.

* * * No Discount

WIRE KITS

Kit No. 1 — $9.95

250	3"	100	4½"
200	3½"	100	5"
100	4"	100	6"

Kit No. 2 — $24.95

250	2½"	250	5"
500	3"	100	5½"
500	3½"	100	6"
500	4"	100	6½"
250	4½"	100	7"

Kit No. 3 — $34.95

250	2½"	500	4½"
500	3"	500	5"
500	3½"	500	5½"
500	4"	500	6"

Kit No. 4 — $59.95

500	2½"	1000	4½"
1000	3"	1000	5"
1000	3½"	1000	5½"
1000	4"	1000	6"

ORDERING INFORMATION

Prepaid orders over $50 shipped prepaid via UPS. All others add $3.00 for handling. VISA, MC, COD's and open account orders will be charged freight. $15 minimum order. $100 minimum open account order.

DISCOUNT SCHEDULE

Order	Amount
$15 - 99	Net
100 - 199	less 10%
200 - 499	less 15%
500 - 999	less 20%
1000 up	less 25%

Discount and the name of this magazine must be mentioned at time of order to get discount. Discount applies on all items except as noted, "No Discount."

ADVANCED COMPUTER PRODUCTS

16K UPGRADE ONLY $24.95 SPECIFY COMPUTER

7400

SN7400N	.19	SN74123N	.59
SN7401N	.22	SN74125N	.39
SN7402N	.22	SN74126N	.44
SN7403N	.22	SN74128N	.59
SN7404N	.22	SN74132N	.59
SN7405N	.23	SN74136N	.75
SN7406N	.23	SN74139N	.95
SN7407N	.23	SN74141N	.79
SN7408N	.26	SN74142N	2.95
SN7409N	.23	SN74143N	2.95
SN7410N	.22	SN74144N	2.95
SN7411N	.29	SN74145N	.62
SN7412N	.29	SN74147N	1.95
SN7413N	.39	SN74148N	1.20
SN7414N	.59	SN74150N	1.09
SN7416N	.29	SN74151N	.67
SN7417N	.29	SN74152N	.67
SN7420N	.22	SN74153N	.67
SN7421N	.35	SN74154N	1.19
SN7422N	.29	SN74155N	.78
SN7423N	.29	SN74156N	.78
SN7425N	.29	SN74157N	.69
SN7426N	.29	SN74158N	1.65
SN7427N	.29	SN74160N	.89
SN7428N	.40	SN74161N	.89
SN7430N	.23	SN74162N	.89
SN7432N	.29	SN74163N	.87
SN7437N	.29	SN74164N	.87
SN7438N	.29	SN74165N	.87
SN7439N	.29	SN74166N	1.20
SN7440N	.19	SN74167N	1.95
SN7441N	.79	SN74170N	1.59
SN7442N	.57	SN74172N	4.75
SN7443N	.85	SN74173N	.79
SN7444N	.85	SN74174N	.89
SN7445N	.79	SN74175N	.85
SN7446N	.79	SN74176N	.75
SN7447N	.66	SN74177N	.75
SN7448N	.79	SN74179N	1.34
SN7450N	.18	SN74180N	.78
SN7451N	.18	SN74181N	1.75
SN7453N	.19	SN74182N	.75
SN7454N	.19	SN74184N	2.25
SN7459N	.25	SN74185N	2.25
SN7460N	.23	SN74186N	9.95
SN7470N	.39	SN74188N	3.90
SN7472N	.29	SN74190N	1.15
SN7473N	.34	SN74191N	1.15
SN7474N	.34	SN74192N	.85
SN7475N	.38	SN74193N	.85
SN7476N	.34	SN74194N	.85
SN7479N	4.60	SN74195N	.85
SN7480N	.48	SN74196N	.85
SN7482N	.95	SN74197N	.85
SN7483N	.56	SN74198N	1.39
SN7485N	.88	SN74199N	1.39
SN7486N	.35	SN74221N	1.19
SN7489N	1.75	SN74251N	.95
SN7490N	.39	SN74273N	1.05
SN7491N	.57	SN74279N	.75
SN7492N	.45	SN74283N	1.40
SN7493N	.43	SN74284N	3.90
SN7494N	.69	SN74285N	3.90
SN7495N	.65	SN74290N	1.25
SN7496N	.69	SN74298N	.95
SN7497N	2.90	SN74365N	.68
SN74100N	1.20	SN74366N	.68
SN74107N	.32	SN74367N	.68
SN74109N	.37	SN74368N	.68
SN74116N	1.95	SN74390N	1.45
SN74121N	.29	SN74393N	1.90
SN74122N	.39	SN74490N	1.90

CMOS

CD4000	.35	CD4098	2.29
CD4001	.35	CD4099	2.25
CD4002	.35	MC14408	12.95
CD4006	1.05	MC14409	12.95
CD4007	.29	MC14410	12.95
CD4008	1.39	MC14412	12.95
CD4009	.45	MC14415	8.95
CD4010	.45	MC14419	4.95
CD4011	.35	CD4501	.39
CD4012	.25	CD4502	1.65
CD4013	.45	CD4503	.69
CD4014	1.39	CD4505	8.95
CD4015	1.15	CD4506	.75
CD4016	.59	CD4507	.95
CD4017	1.19	CD4508	3.75
CD4018	.89	CD4510	1.19
CD4019	.45	CD4511	1.19
CD4020	1.10	CD4512	1.39
CD4021	1.19	CD4515	2.75
CD4022	1.15	CD4516	1.45
CD4023	.29	CD4518	1.39
CD4024	.75	CD4520	1.25
CD4025	.25	CD4555	4.95
CD4027	.65	CD4556	.99
CD4028	.85	CD4566	2.25
CD4029	1.29	74C00	.35
CD4030	.45	74C02	.35
CD4031	3.25	74C04	.35
CD4032	2.15	74C08	.35
CD4034	3.25	74C10	.35
CD4035	.95	74C14	.72
CD4037	1.95	74C20	.35
CD4040	1.29	74C30	.35
CD4041	1.25	74C32	.99
CD4042	.95	74C42	1.35
CD4043	.85	74C48	1.89
CD4044	.85	74C73	.75
CD4046	1.75	74C74	.75
CD4047	1.25	74C85	1.79
CD4048	.99	74C89	5.95
CD4049	.45	74C90	1.19
CD4050	.69	74C93	1.19
CD4051	1.10	74C95	1.49
CD4052	1.10	74C107	1.19
CD4053	1.10	74C151	2.49
CD4055	3.95	74C154	3.50
CD4056	2.95	74C157	2.10
CD4059	9.25	74C160	1.65
CD4060	1.39	74C161	1.55
CD4066	.75	74C163	1.65
CD4069	.35	74C164	1.55
CD4070	.49	74C173	1.35
CD4071	.35	74C174	1.35
CD4072	.35	74C175	1.35
CD4073	.35	74C192	1.65
CD4075	.35	74C193	1.65
CD4076	1.29	74C195	1.55
CD4077	.35	74C240	2.19
CD4078	.35	74C244	2.19
CD4081	.35	74C373	2.39
CD4082	.35	74C374	2.39
CD4085	1.95	74C922	5.39
CD4089	2.95	74C923	5.65
CD4093	.99	MM80C95	1.50
CD4094	2.95	MM80C97	1.25

74LS00

74LS00N	.26	74LS164N	1.19
74LS01N	.28	74LS165N	.89
74LS02N	.28	74LS166N	2.48
74LS03N	.28	74LS168N	1.15
74LS04N	.35	74LS169N	1.15
74LS05N	.28	74LS170N	1.98
74LS08N	.28	74LS173N	.89
74LS09N	.35	74LS174N	.89
74LS10N	.28	74LS175N	.89
74LS11N	.39	74LS181N	2.20
74LS12N	.33	74LS190N	1.15
74LS13N	.47	74LS191N	1.15
74LS14N	.95	74LS192N	.98
74LS15N	.33	74LS193N	.98
74LS20N	.26	74LS194N	1.15
74LS21N	.33	74LS195N	.95
74LS22N	.33	74LS196N	.89
74LS26N	.33	74LS197N	.89
74LS27N	.33	74LS221N	1.15
74LS28N	.33	74LS240N	1.89
74LS30N	.26	74LS241N	1.89
74LS32N	.33	74LS242N	1.89
74LS33N	.55	74LS243N	1.49
74LS37N	.45	74LS244N	1.49
74LS38N	.39	74LS245N	2.20
74LS40N	.26	74LS247N	1.10
74LS42N	.79	74LS248N	1.10
74LS47N	.79	74LS249N	1.19
74LS48N	.95	74LS251N	1.40
74LS51N	.26	74LS253N	.98
74LS54N	.29	74LS257N	.85
74LS55N	.29	74LS258N	.98
74LS73N	.45	74LS259N	2.95
74LS74N	.42	74LS260N	.65
74LS75N	.59	74LS261N	2.48
74LS76N	.45	74LS266N	.59
74LS78N	.45	74LS273N	1.75
74LS83AN	.79	74LS275N	4.40
74LS85N	1.19	74LS279N	.59
74LS86N	.45	74LS283N	.89
74LS90N	.57	74LS290N	.98
74LS92N	.75	74LS293N	.89
74LS93N	.75	74LS295N	1.10
74LS95N	.88	74LS298N	1.19
74LS96N	.98	74LS324N	1.75
74LS107N	.45	74LS347N	1.85
74LS109N	.45	74LS348N	1.85
74LS112N	.43	74LS352N	1.19
74LS113N	.43	74LS353N	1.19
74LS114N	.43	74LS363N	1.49
74LS122N	.55	74LS365N	.89
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74LS125N	.89	74LS368N	.89
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74LS138N	.85	74LS377N	1.89
74LS139N	.85	74LS385N	1.85
74LS145N	1.25	74LS386N	.65
74LS148N	1.49	74LS390N	1.95
74LS151N	.79	74LS393N	1.95
74LS153N	.79	74LS395N	1.70
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74LS155N	1.19	74LS424N	2.95
74LS156N	.99	74LS668N	1.75
74LS157N	.85	74LS670N	2.29
74LS158N	.75	81LS95N	1.69
74LS160N	1.05	81LS96N	1.69
74LS161N	1.15	81LS97N	1.69
74LS162N	1.05	81LS98N	1.69
74LS163N	1.09		

LINEAR

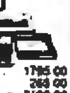
78H05	5.95	MC1358	1.75
78M05	1.49	LM1414N	1.90
78M G	1.49	LM1458CN/H	.49
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LM339N	.95	CA3080T	1.29
LM340K-XX*	1.75	CA3081N	1.69
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LM376N	3.75	CA3146N	2.49
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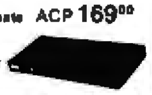
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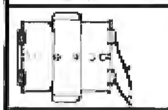
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102 P20	Xformer for MA1023, 1043 & 5036 Mods	3.49
102 P22	Xformer for MA1026 Clock Modules	3.49
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- Holds 2 ea. C cells
- Aluminum Case
- 5" leads

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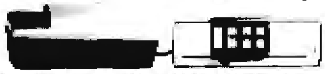
BATTERY HOLDER

BH82721

- Holds 4 ea. C cells
- Plastic case
- 9" leads

$.48 ea. 10/$4.25

EPROM Erasing Lamp

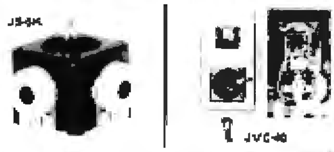


- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
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- Complete with holding tray for 4 chips.

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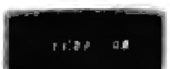
UVS-11E $79.95

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- Bright .300 ht. comm. cath-ode display
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(Picture not shown but similar in construction to above)

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JE210	Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp	$19.95

MICROPROCESSOR COMPONENTS

—8080A/8080A SUPPORT DEVICES—

[illegible]	CPU	[illegible]
[illegible]	8-Bit Input/Output	[illegible]
[illegible]	Priority Interrupt Control	[illegible]
[illegible]	Bi-Directional Bus Driver	[illegible]
[illegible]	Clock Generator/Driver	[illegible]
[illegible]	Bus Driver	[illegible]
[illegible]	System Controller/Bus Driver	[illegible]
[illegible]	System Controller	[illegible]
[illegible]	I/O Expander for 48 Series	[illegible]
[illegible]	Asynchronous Comm. Element	[illegible]
[illegible]	Prog. Comm. I/O (USART)	[illegible]
[illegible]	Prog. Interval Timer	[illegible]
[illegible]	Prog. Peripheral I/O (PPI)	[illegible]
[illegible]	Prog. DMA Control	[illegible]
[illegible]	Prog. Interrupt Control	[illegible]
[illegible]	Prog. CRT Controller	[illegible]
[illegible]	Prog. Keyboard/Display Interface	[illegible]
[illegible]	System Timing Element	[illegible]
[illegible]	8-Bit Bi-Directional Receiver	[illegible]
[illegible]	8-Bit Bi-Directional Receiver	[illegible]
[illegible]	8-Bit Bi-Directional Receiver	[illegible]
[illegible]	Octal Latched Peripheral Driver	[illegible]
[illegible]	Octal Latched Peripheral Driver	[illegible]

—6800/6800 SUPPORT DEVICES—

MC6800	MPU	[illegible]
MC6802CP	MPU with Clock and RAM	[illegible]
[illegible]	128x8 Static RAM	[illegible]
[illegible]	Peripheral Inter. Adapt. (MC6820)	[illegible]
[illegible]	Priority Interrupt Controller	[illegible]
[illegible]	1024x8 Bit ROM (MC68A30-8)	[illegible]
[illegible]	Asynchronous Comm. Adapter	[illegible]
[illegible]	Synchronous Serial Data Adapter	[illegible]
[illegible]	0-600bps Digital MODEM	[illegible]
[illegible]	1 Kbps Modulator	[illegible]
[illegible]	Quad 3-State Bus Trans. (MC8T26)	[illegible]

—MICROPROCESSOR CHIPS—

Z80 (780C)	CPU (MK3880N) (2MHz)	[illegible]
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	[illegible]
CDP1802	CPU	[illegible]
[illegible]	CPU	[illegible]
[illegible]	CPU with on-chip clock (Com. Temp. Grade)	[illegible]
[illegible]	MPU w/Clock RAM (Data Memory)	[illegible]
[illegible]	MPU (8 Bit Static)	[illegible]
[illegible]	CPU [illegible]	[illegible]
[illegible]	[illegible]	[illegible]

—SHIFT REGISTERS—

[illegible]	[illegible]	[illegible]

—DATA ACQUISITION—

[illegible]	Universal Active Filter	[illegible]
[illegible]	Touch Tone Low Band Filter	[illegible]
[illegible]	Touch Tone High Band Filter	[illegible]
[illegible]	Super Gain Op Amp	[illegible]
[illegible]	Constant Current Source	[illegible]
[illegible]	Temperature Transducer	[illegible]
[illegible]	JFET Input Op Amp	[illegible]
[illegible]	Sample & Hold Amplifier	[illegible]
[illegible]	[illegible]	[illegible]
ADC0804LCN	8-Bit A/D Converter [illegible]	[illegible]
DAC0808LCN	8-Bit D/A Converter [illegible]	[illegible]

—DATA ACQUISITION (CONTINUED)—

ADC0808CCN	8-Bit A/D Converter (8-Ch. Multi.)	[illegible]
ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	[illegible]
DAC[illegible]LCN	10-Bit D/A Conv. Micro. Comp. [illegible]	[illegible]
DAC[illegible]LCN	10-Bit D/A Conv. Micro. Comp. [illegible]	[illegible]
DAC[illegible]LCN	8-Bit D/A Converter (0.2% Lin.)	[illegible]
DAC[illegible]LCN	8-Bit D/A Converter (0.39% Lin.)	[illegible]
DAC[illegible]LCN	8-Bit D/A Converter (0.78% Lin.)	[illegible]
[illegible]	8 Channel Multiplexer	[illegible]
AY-5-1013	30K BAUD UART	[illegible]

—RAM'S—

[illegible]	[illegible] Static	[illegible]
[illegible]	[illegible] Dynamic	[illegible]
[illegible]	[illegible]	[illegible]

—PROMS/EPROMS—

1702A	2K UV Erasable PROM	[illegible]
2708	8K EPROM	[illegible]
[illegible]	16K EPROM (+5V, -5V, +12V)	[illegible]
[illegible]	16K EPROM (Single +5V)	[illegible]
[illegible]	32K EPROM	[illegible]
[illegible]	64K EPROM [illegible]	[illegible]
[illegible]	64K EPROM [illegible]	[illegible]
[illegible]	[illegible] PROM	[illegible]
[illegible]	[illegible]	[illegible]

—ROM'S—

[illegible]	Character Generator (Upper Case)	[illegible]
[illegible]	Character Generator (Lower Case)	[illegible]

—NMOS READ ONLY MEMORIES—

[illegible]	[illegible] ASCII [illegible]	[illegible]
[illegible]	[illegible] Math Symbol & Pictures	[illegible]
[illegible]	[illegible] Alpha. Control Char. Gen.	[illegible]

—MICROPROCESSOR MANUALS—

[illegible]	User Manual	[illegible]
[illegible]	User Manual	[illegible]
[illegible]	User Manual	[illegible]

—SPECIAL FUNCTION—

[illegible]	Dual MOS Clock Driver [illegible]	[illegible]
[illegible]	Dual MOS Clock Driver [illegible]	[illegible]
[illegible]	Floppy Disc Controller	[illegible]
[illegible]	Communication Chip	[illegible]
[illegible]	Microprocessor Real Time Clock	[illegible]
[illegible]	Microprocessor Compatible Clock	[illegible]
[illegible]	Microcontroller with [illegible]	[illegible]
[illegible]	Microcontroller with 8-Digit RAM & Drive LED Drive	[illegible]
[illegible]	[illegible] VAC Fluor. Driver [illegible]	[illegible]

—TELEPHONE/KEYBOARD CHIPS—

[illegible]	Push Button Telephone Dialer	[illegible]
[illegible]	Repertory Dialer	[illegible]
[illegible]	CMOS Clock Generator	[illegible]
[illegible]	Keyboard Encoder [illegible]	[illegible]
[illegible]	Keyboard Encoder [illegible]	[illegible]
[illegible]	Keyboard Encoder [illegible]	[illegible]
[illegible]	Keyboard Encoder [illegible]	[illegible]
[illegible]	Push Button Pulse Dialer	[illegible]
[illegible]	Multi-Key Serial Keyboard Encoder	[illegible]

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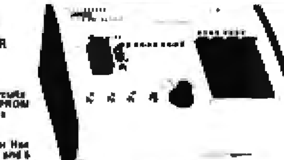


.937 O.D. x 1.20 Length

TYPICAL CHARACTERISTICS											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1.50	1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

MABUCHI RE260 $.99 each . . . 10/$7.50 . . . 100/$50.00

JE608 PROGRAMMER
2704/2708 EPROM PROGRAMMER



GENERAL APPLICATIONS:
- To program EPROMS 2704 and 2708
- Developmental system for microcomputer circuits
- To read the contents of a pre-programmed EPROM
- To compare EPROM(s) for content differences
- To emulate a programmed EPROM
- To store program in RAMS for alterations
- Three separate Display Registers: 8 LED's for Hex Numerals, 10 LED's (2¹⁰) for Address Register and 8 LED's for Data Memory Register. The Data Memory Register displays the content of the RAMs from the EPROM Chip. Development of microprocessor systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board. Rapid checking verification of programmed data changes. User may move data from a master to RAM's or write into RAM's with keyboard entries. Allows manual stepping manipulation (up and down) at any address location. Stand-alone EPROM Programmer consisting of: A 19-key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and 1 LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 8W. Compact desk-top enclosure. Color coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3¾"H x 11"W x 8¾"D. Weight: 3 lbs.

The JE608 EPROM Programmer is a complete self contained unit which is independent of computer control and requires no additional systems for its operation. The EPROM can be programmed from the Hexadecimal Keyboard or from a pre-programmed EPROM. The JE608 Programmer can emulate a programmed EPROM by the use of its internal RAM circuits. This will allow the user to test or debug a program in his system, prior to programming a chip. Any changes in the program can be entered directly into the memory circuits with the Hexadecimal Keyboard so that rewriting the entire program will not be necessary. The JE608 Programmer contains a Programmer Board with 36 IC's & includes power supplies of -5V, +5V, +12V and +26V. The Hexadecimal Keyboard and LED/Test Socket Panel board are separate assemblies within the system.

JE608K Kit $399.95
JE608A Assembled and Tested $499.95

JE608-16K ADAPTER BOARD
FOR 2716/2758 EPROMS

GENERAL DESCRIPTION
The JE608-16K Adapter Board allows the JE608 Programmer to be modified for the additional programming of the 2716 and 2758 EPROMS. The adapter provides for adding an address switch for the 2ⁿ bit and also for selecting the proper power and timing pulses to be applied to the EPROM. Programming and emulating the 2716/2758 EPROM is done separately to each half (1024x8) of the EPROM because of the existing 8K RAM capacity in the JE608 Programmer.

JE608-16K	Adapter Board Kit	$29.95
JE608-Upgrade	(Send assembled JE608 to factory for adapter installation . . . . of the JE608-16K Adapter Board Kit)	$59.95
JE608A-16K Mod.	Assembled JE608 w/Adapter (JE608-16K) Installed	$699.95

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BOOKS
National Semiconductor — Intersil — Intel

30001	National CMOS Data Book . . . . (640 pages) 74C, CD4000, and A/D Converters	[illegible]
30002	National Interface Data Book . . . . (704 pages) DP, DS8000, DS8800, DS75000, etc.	[illegible]
30003	National Linear Data Book . . . . (1376 pages) LM, LF, ADC, DAC, LH Series	$7.95
30004	National Series 80 – Board Level Computer (224 pages)	$4.95
30005	National TTL Logic Data Book . . . . (424 pages) 7400, LS, L, H, S, and DM8000 Series	[illegible]
30006	Buy above (5) 30001, 2, 3, 4, 5 as a set	[illegible]
30009	Intersil Data Book (1979 pages)	[illegible]
210830	Intel Component Data Catalog . . . . Full data sheets for Intel's products incl. memory devices, microprocessors, peripherals & industr. tmp. products (1000 pages)	$10.00
205775	Intel Peripheral Design Handbook . . . . Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$7.95

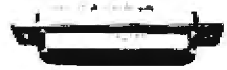
AC and DC Wall Transformers



Ideal for use with clocks, games, power supplies or any other type of AC or DC application.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$3.95
DV 9200	117V/60Hz	9 VDC 200mA	$3.25
DC 900	120V/60Hz	9 VDC 500mA	$3.95

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
★ 8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (*NS)
★ Documentation for Conversion

TRS-16K2	*150NS	$29.95
TRS-16K3	*200NS	$24.95
TRS-16K4	*250NS	$19.95

JE610 ASCII Encoded Keyboard Kit



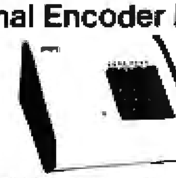
The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62 keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and –12V @ 10 mA for operation. Features: 60 keys generate the 128 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3¼"H x 14¾"W x 6¾"D

JE610/DTE-AK (After assembled as pictured above) . . . **$124.95**
JE610 Kit 62-Key Keyboard, PC Board, & Components (no case) . . . **$ 79.95**
K62 62-Key Keyboard (Keyboard only) . . . **$ 34.95**
DTE-AK (case only – 3¼"H x 14¾"W x 6¾"D) **$ 49.95**

NEW! JE212 – Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT
Provides -12VDC from incoming 5VDC . . . $9.95

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD



The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3⅝"H x 6⅝"W x 6⅝"D

JE600/DTE-HK (After assembled as pictured above) . . . **$99.95**
JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . . **$59.95**
K19 19-Key Keyboard (Keyboard only) . . . **$14.95**
DTE-HK (case only – 3⅝"H x 6⅝"W x 6⅝"D) **$44.95**

Circle 189 on inquiry card.



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SALE PRICE **$129.00**

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P= Plug, Male Type -S= Socket, Female Type -C= Cover, Hood

PART NO.	DESCRIPTION	PRICE 1-9	10-24	25-99
CND-DE9P	9 pin male	$ 2.10	$ 1.90	$ 1.70
CND-DE9S	9 pin female	$ 2.70	$ 2.40	$ 2.10
CND-DE9C	9 pin cover	$ 1.50	$ 1.25	$ 1.10
CND-DA15P	15 pin male	$ 2.75	$ 2.45	$ 2.15
CND-DA15S	15 pin female	$ 3.95	$ 3.60	$ 3.20
CND-DA15C	15 pin cover	$ 1.50	$ 1.20	$ 1.10
CND-DB25P	25 pin male	$ 3.50	$ 3.25	$ 3.00
CND-DB25S	25 pin female	$ 4.00	$ 4.35	$ 4.20
CND-DB51212	1 pc. grey hood	$ 1.60	$ 1.45	$ 1.30
CND-P25H	2 pc. grey hood	$ 1.50	$ 1.25	$ 1.10
CND-DB51226	2 pc. black hood	$ 1.90	$ 1.65	$ 1.45
CND-DC37P	37 pin male	$ 5.00	$ 5.10	$ 4.45
CND-DC37S	37 pin female	$ 4.70	$ 7.70	$ 6.70
CND-DC37C	37 pin cover	$ 1.00	$ 1.55	$ 1.30
CND-DD50P	50 pin male	$ 8.75	$ 7.75	$ 6.70
CND-DD50S	50 pin female	$11.65	$10.25	$ 8.90
CND-DD50C	50 pin cover	$ 2.00	$ 1.80	$ 1.60
CND-D20418	Hardware set 2 pr RS232, DB25P, EIA	$ 1.00	$ .80	$ .70
CND-RS232GF	Class 1 cable 9 con 8 ft Cent. 700 Series	$19.95	$17.95	$15.95
CND-5730360	Printer connector	$ 9.00	$ 7.50	$ 6.00

MICROCOMPUTER PRODUCTS

PART NO.	PRICE
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2114N3L	8/$20.00
4257N3L	8/$50.00
2732	8/$120.00
2716	8/$50.00
2708	8/$32.00

8080 SERIES

PART NO.	PRICE
INS 8080A	$5.50
INS 8085A	$19.95
DP8212N	$2.95
DP8214N	$5.25
DP8216N	$2.95
DP8224N	$3.25
DP8224-4N	$9.95
DP8226N	$3.50
DP8228N	$5.55
DP8238N	$5.55
INS8250N	$15.00
INS8251N	$7.50
INS8253N	$17.95
INS8255N	$8.80
INS8257N	$16.45
INS8259N	$18.00
INS8275N	$59.95
INS8279N	$49.95

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Z80ADMA	$45.00
Z80AS100	$59.95
Z80AS101	$59.95
Z80AS102	$59.95

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FD1771B-01	$24.95
FD1791B-01	$44.95

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6502	$12.95
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6522	$10.95
6530-002	$21.95
6530-003	$21.95
6530-004	$21.95
6530-005	$21.95
6532M	$21.95
6551M	$21.95

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PART NO.	PRICE
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MC6808P	$9.95
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MC6821P	$5.95
MC6828P	$14.95
MC6840P	$14.95
MC6845P	$31.00
MC6847P	$14.95
MC6850P	$5.41
MC6852P	$5.79
MC6854P	$24.95
MC6860P	$10.69
MC6862P	$12.00
MC6875L	$7.40
MC68710P	$12.50
MC68750P	$12.50

UARTS

PART NO	PRICE
AY51013A	$5.95
TR1602B	$5.95
TR1863	$6.95
IM6402	$7.95

CompuPro™ from GODBOUT ELECTRONICS

10 MHZ 16K A&T STATIC S-100 RAM

GBT-143A

List $349.00 **$169.00 Ea**

3/$450.00



- Operates up to 10 MHZ (90 ns RAM Chips)
- Assembled & Tested
- Meets or exceeds all IEEE 696/S-100 specifications (including timing).
- Fully static design eliminates the timing problems associated with dynamic memories.
- Switch selectable choice of 24 address lines conforming to the IEEE 696/S-100 extended addressing specifications, or 16 address lines as used in older S-100 systems.
- Ideal for multi-user installations.
- Board is addressable as one 16K x 8 block on any 4K boundary.
- Switch selectable PHANTOM disable and write protect.
- + 5 Volt operation (requires no other supply voltages).
- Low power operation (900 mA typical, 1200 mA maximum).
- 1 year Factory Warranty.



S-100 "ANY DIP" has full power and ground planes back to back. Boards accommodates .3, .4, .6, .9" Dips.

1-4	5-9	10-24
$24.67	$22.34	$20.02

APPLE PLUGBOARD

Vector 4609 Peripheral Interface Plugboard for construction of custom circuits. Plug compatible with Apple II, Commodore PET and Super Kim microcomputers. VCT-4609

1-4	5-9	10-24
$20.74	$18.79	$16.84



Universal Microcomputer/processor plugboard use with S-100 bus. Complete with heat sink & hardware 53" x 10" x 1/16".

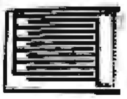
1-4	5-9	10-24
$22.48	$20.37	$18.28

VCT-8801-1

Same as 8800V except plain, less power buses & heat sink

1-4	5-9	10-24
$15.67	$14.24	$12.62

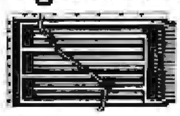
Vector Plugboards



VCT-3682 9.6" x 4.5" $13.63

VCT-3682-2 6.5" x 4.5" $11.04

Hi-Density Dual-In-Line Plugboard for Wire Wrap with Power & Grd. Bus Epoxy Glass 1/16" 44 pin con. spaced .156

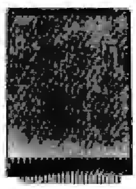


VCT3677 9.6"x4.5"

VCT-3677 96" x 4.5" $13.33

VCT-3677-2 6.5" x 4.5" $10.60

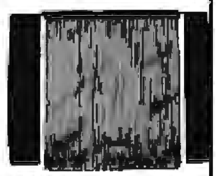
Gen Purpose D.I.P. Boards with Bus Pattern for Solder or Wire Wrap. Epoxy Glass 1/16" 44 pin con. spaced .156



VCT-3662 6.5" x 4.5" $9.69

VCT-3662-2 9.6" x 4.5" $10.85

P pattern plugboards for IC's Epoxy Glass 1/16" 44 pin con. spaced .156



VCT-3690-12 $26.64

CARD EXTENDER

Card Extender has 100 contacts 50 per side on 125 centers. Attached connector is compatible with S-100 Bus Systems

VCT-3690 6.5" 22/44 pin .156 ctrs. Extenders . . . $16.06



1/16 Vector BOARD

.042 diaholes on 0.1 spacing for IC's

PART NO.	SIZE	PRICE 1-9	10-19
Phenolic			
VCT-64P44-X	4.5" x 6.5"	$1.56	$1.40
VCT-169P44-X	4.7" x 17"	$3.69	$3.32
Epoxy Glass			
VCT-64P44	4.5" x 6.5"	$1.83	$1.65
VCT-84P44	4.5" x 8.5"	$2.25	$2.03
VCT-169P44	4.5" x 17"	$4.61	$4.15
VCT-169P48	8.5" x 17"	$9.00	$8.10

TRS-80/APPLE MEMORY EXPANSION KITS

4116's RAMS

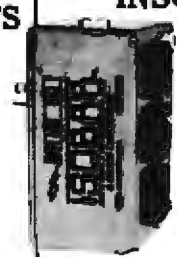
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Add $3.00 for programming Jumpers for TRS-80 Keyboard

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SH. WT. 3 lbs.

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16 PIN LOW PROFILE I.C.

C-35 BOOKETS

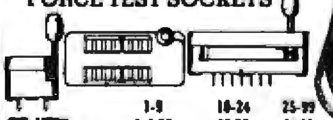


TIG-16LP pkg. of 100 $16.00

TIG-16LP pkg. of 1000 $120.00

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ZERO INSERTION FORCE TEST SOCKETS



	1-9	10-24	25-99
ZIP-16DIP	$ 5.50	$5.35	$4.95
ZIP-24DIP	$ 7.50	$7.25	$6.95
ZIP-40DDIP	$10.25	$9.85	$9.50



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SH. WT. 5 LBS.

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GOF-CR50 50 ft Cord $40.95

1M-10A List $104.95

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Circle 305 on inquiry card.

PRIORITY ONE ELECTRONICS



ONE

PRICE $1095.00 SAVING: $429.00

SOURCE: *PRIORITY 1 ELECTRONICS* Manufacturer: COMPUPRO From GODBOUT (Of Course)

CPU-Z

The **CPU Z** board is an 8 bit workhorse that not only includes all standard Z80A* features, but also has the necessary options to ensure backward compatibility with most older S-100 mainframes. This board optionally runs at slower clock speeds if needed, generates MWRITE for systems requiring this signal, and even includes a plug that accepts the connector from an IMSAI type front panel. Other features include:

- Full compliance with all IEEE 696/S-100 specifications (including timing specifications).
- Downward compatible with the vast library of 8080 software.
- 24 bit addressing allows access to 16 megabytes of memory.
- Ideal for multi-user installations.
- Designed for high speed operation that greatly increases system throughput (switch selectable choice of 2 or 4 MHz operation for **Assembled/Tested** boards; choice of 3 or 6 MHz for boards qualified under the **CSC** high-reliability program).
- Provision for adding up to 8 kilobytes of on-board memory (2716/2732 EPROMs or 6116 RAMs—not included with board).
- On-board memory sockets may be disabled under software control to allow overlapping RAM.
- On-board fully maskable vectored interrupts for interrupt driven systems.
- Power-on clear (POC) generates SLAVE CLR* and pRESET*.
- Selectable automatic wait state insertion for servicing M1* instructions—MRQ*—I/ORQ*— or the on-board memory (may be inserted in any or all of the above).
- Automatic jump upon Reset or power-on to any 256 byte boundary.
- Non-maskable interrupt on bus pin 12, as per IEEE 696 specs.

This powerful and flexible CPU board provides the sophisticated operation required by today's S-100 computers, while allowing for complete compatibility with older systems as well. But perhaps best of all, **CPU Z** is cost-competitive with boards that do considerably less. When you need a powerful 8 bit CPU board that is at home with the latest (as well as some of the earliest) S-100 systems, **CPU Z** is the answer.

DISK 1
HIGH PERFORMANCE FLOPPY DISK CONTROLLER

Finally, a floppy disk controller worthy of bearing the **CompuPro** name is now available for integration into your S-100 system. The **DISK 1** floppy controller incorporates numerous features that were previously unavailable on a DMA floppy disk controller board. **DISK 1** fully complies with the IEEE 696 bus standard, **INCLUDING DMA ARBITRATION!**

- Third generation INTEL 8272/NEC 765A LSI floppy disk controller.
- High speed cycle stealing DMA interface for processor independent data transfer between system memory and flexible disk.
- Handles up to four 8 or 5.25 inch floppy disk drives.
- Single or double density/single or double sided capability.
- Supports IBM 3740 soft sectored formats.
- 24 bit DMA addressing with data transfer across 64 K boundaries for data transfer throughout the 16Mbyte memory map.
- I/O mapped interface allows contiguous system memory. (**DISK 1** occupies no memory space)
- On board Phantom boot EPROM for automatic startup.
- On board serial port for initial system startup.
- Board compatible with MP/M, OASIS, CP/M-80 and CP/M-86.
- CP/M-80 and CP/M-86 available for **DISK 1**.
- CPU speed independent data transfer for operation up to 10MHz.
- Fully arbitrated DMA interface as per IEEE 696 for allowing multiple DMA devices without conflict.
- May be interrupt driven for multi-user environments.
- Up to 600K bytes per side (8 inch drive) for an on-line total of up to 4.8M bytes (4 drives - double sided-double density).

All these features should convince you that **DISK 1** is the only choice when creating the highest performance S-100 disk system available - day and in the future. The **DISK 1** provides the advanced capabilities required by high performance single and multi-user microcomputer systems. Whether designing a new disk system or upgrading a lower performance disk system, **DISK 1** yields the best cost/performance ratio available today.

RAM 20 10 MHz
32K STATIC RAM

You don't have to pay a lot of money for a lot of memory: despite the surprisingly low price, **RAM 20** includes all the features that you would expect in a memory board where cost is no object. Available in 16K, 24K, and 32K configurations, **RAM 20** includes the most sought after features for any quality memory board:

- Meets or exceed all IEEE 696/S-100 specifications (including timing)
- Fully static design eliminates the timing problems associated with dynamic memories.
- Switch-selectable choice of 24 address lines conforming to the IEEE 696/S-100 extended addressing (16 megabyte) specification, or 16 address lines as used in bank select and older S-100 systems, memory addressing (including Cromemco, Alpha Micro, and others) as well as newer systems conforming to the IEEE 696 extended addressing protocol
  addressing protocol.
- Ideal for multi-user installations.
- CSC and Assembled/Tested boards are designed for CPU speeds up to 10 MHz
- Board is addressable as one 32K x 8 block on any 4K boundary
- Each 4K row can be individually disabled via DIP switch.
- Switch selectable PHANTOM disable and write protect.
- +5 Volt operation (required no other supply voltages).
- Thorough bypassing of all supply lines.
- Careful thermal design to minimize heat build-up.
- Heavy power and ground traces.
- Low power operation (1200 mA typical, 1500 mA maximum).

RAM 20 delivers the high-density memory needed by every S-100 computer system - in a cost-effective and exceptionally well-designed package. Whether for 24 bit address systems or bank select systems,

RAM 20 provides economical and cost-effective mass storage.

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Deduct 10% from our already discounted prices on GODBOUT & TEI. Mainframes if ordered with any of these specials.

Circle 306 on inquiry card.

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Dual Processer Board. With this high speed board (5 MHz operation), you have the capability to use the vast library of 8 bit software available today, as well as the enhanced 16 bit software being developed at major software houses for tomorrow's demanding applications.

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128K of Static RAM. The best components deserve the best memory, which is why 128K of our famous high speed(10MHz)/low power ram comes standard with every **SuperSixteen** package.

CP/M*-2.2. The most popular 8 bit operating system, ready to load and go.

CP/M*-86. Rady to load and go for 16 bit operation.

Cables and Documentation. Each package includes three interfacer cables, one disk I/O cable, complete documentation for all hardware, and manuals for both CP/M* operating systems.

Now to the best part of all. If purchased separately, these quality components would list for $4,344. **But SuperSixteen's low package price is an amazing $3,495.**

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(For boards qualified under the Certified System Component high-reliability program - with extended 2 year warranty, 200 hour burn-in, and 6 MHz processors - add $600 to the package price. Standard **SuperSixteen** packages come with usual 1 year limited warranty.)

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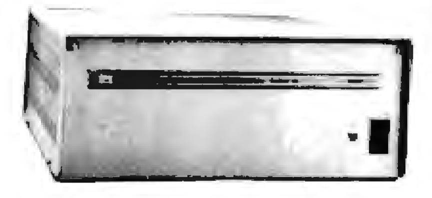
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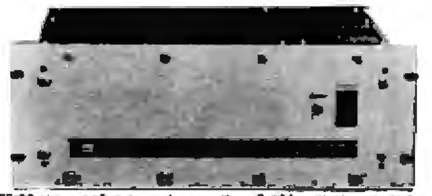
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TEI MicroFrame®



From the power supply through the sturdy chassis, TEI constructs and assembles each mainframe with great care. Every TEI mainframe utilizes a constant voltage transformer (CVT) which delivers clean regulated power at the proper level, reducing the heat in the computer cards. The output voltage on the transformer remains nearly even with the input voltage varying from approximately 85V to 140V. This means the mainframe will never notice voltage variations or even a brownout. It also provides 100 dB noise erjection to protect the computer from voltage spikes and line noise.

No need for a dedicated line or expensive noise filters. TEI was the first manufacturer to offer the CVT in its complete computer product line and is still on of few manufacturers to offer the CVT as standard equipment.



TEI 22 slot and 12 slot mainframes offer a S-100 motherboard which is grounded, shielded and actively terminated for high speed operation now or for later upgrading. Each mainframe is shipped completely assembled, tested and burned in, with fan, washable filter, all connectors and card guides. Rackmount models are available in both 22 and 12 slot mainframes. The combination of the lowest noise bus, a regulated CVT power system and a rugged chassis produces a mainframe without equal.

S-100 MAINFRAMES

		LIST PRICE	OUR PRICE
TEIMCS 112	12 Slot Desk	$685.00	$615.00
TEIMCS 122	22 Slot Desk	$845.00	$760.00
TEIRM 12	12 Slot Rackmount	$800.00	$720.00
TEIRM 22	22 Slot Rackmount	$945.00	$850.00

Shipping Weight On 12 Slot Mainframes 35 lbs.
On 22 Slot Mainframes 50 lbs.
12 slot + 8V @ 17A ± 16V @ 2A, 35 lbs.
22 slot + 8V @ 30A ± 16V @ 4A, 50 lbs.
Shipping Weight On 12 Slot Mainframes 40 lbs.
On 22 Slot Mainframes 55 lbs.



S-100 MAINFRAME WITH 12 SLOT MOTHERBOARD AND CUTOUTS FOR 3 5¼" FLOPPY DISK DRIVES

		LIST PRICE	OUR PRICE
TEITF12	12 Slot Desk	$695.00	$625.00
TEIRF12	12 Slot Rackmount	$795.00	$715.00

DUAL 8" DISK DRIVE CHASSIS

For Shugart 800/801R with external power cables provided.

		LIST PRICE	OUR PRICE
TEIDF00	Desk Top	$535.00	$485.00
TEIRF00	Rack Mount	$725.00	$670.00

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ONE



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SPECIFICATIONS: 165 CPS • 132 char per line • Graphics res 60HX 72V • Adj. tractor feed 3" to 16" width • 10 character per inch or 5 expanded lines per inch 2, 3, 4, 5, 6, 8, 10 for alpha numerics 12 for graphics • paper load front or bottom • complete self test mode • self-contained intelligent controller card handles both serial and parallel interfaces • audible signaling • out of paper detection • bidirectional w/logic seeking.

MALIBU165	Serial/Parallel Interface	**$1595.00**
MALIBU1652	Parallel only Interface	**$1465.00**

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CompuPro™ from GODBOUT ELECTRONICS



Now...a place to put this CompuPro or other S-100 boards. The enclosures are available in either desk top or rack mount (including slides) and both have the following features:

Enclosure

- Quiet fan provides for cool system operation.
- Two switched convenience outlets on the rear.
- Line filter for electrical noise suppression.
- *dCircuit breaker for safe operation.*
- Lighted RESET BUTTON FOR "POWER ON" indication.
- Punchouts on rear for 12 DB-25 connectors.
- Punchouts on rear for 2 DD-50 connectors.
- Positive pressurized for ease of filtration.
- Provisions for mounting a front panel.
- Physically 18.5" deep, 7" high, 17" wide (rack front panel 19" wide).

Motherboard

- Actively terminated at both ends of motherboard.
- Ground shield between every signal trace.
- Convenient power plug for connecting all D.C. power
- RESET connector provided.
- Front panel provisions on the 20 slot version.
- Extra power connectors for more efficient power distribution 12 slot and 20 slot versions.
- Thorough by passing of all power lines.

Power Supply

- Twenty-five Amps at 8.0 volts D.C.
- Three Amps each at + 16 and - 16 volts D.C.
- Outputs vary less than 5% over input range of 100 AC to 130 VAC.
- Constant voltage transformer.
- All outputs fused.

With all the features listed above, the individual assembling a system can be sure that he will have the very best foundation possible for an IEEE 696-s-100 system that will give years of reliable service. And because of the constant voltage transformer the power outputs can be kept near the minimum required with no worry about system failure. This allows the system to run cooler, and the regulators to stay cooler also.

		LIST PRICE	OUR PRICE
GBTENC20RM	20 Slot Rack Mount	$895.00	$825.00
GBTENC20DK	20 Slot Desk Top	$825.00	$760.00

Shipping Weight 55 lbs.

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74LS21	38	74LS194	1.00
74LS22	.25	74LS195	95
74LS26	.38	74LS196	85
74LS27	38	74LS197	.85
74LS28	35	74LS221	1.20
74LS30	.28	74LS240	1.89
74LS32	.38	74LS241	1 85
74LS33	.55	74LS242	1 85
74LS37	88	74LS243	1 85
74LS38	.38	74LS244	1.75
74LS40	.25	74LS245	2.85
74LS42	.55	74LS247	78
74LS47	78	74LS248	1 25
74LS48	75	74LS249	99
74LS49	78	74LS251	1.30
74LS51	26	74LS253	85
74LS54	35	74LS257	85
74LS55	38	74LS258	85
74LS63	1 25	74LS259	2 85
74LS73	.40	74LS260	.65
74LS74	48	74LS266	55
74LS75	50	74LS273	1 65
74LS76	40	74LS275	3.35
74LS78	50	74LS279	.55
74LS83	75	74LS280	1.98
74LS85	1.18	74LS283	1 00
74LS86	40	74LS290	1.25
74LS90	.65	74LS293	1.88
74LS91	89	74LS295	1.05
74LS92	70	74LS298	1.20
74LS93	65	74LS324	1.75
74LS95	88	74LS352	1.55
74LS96	95	74LS353	1.55
74LS107	.40	74LS363	1 35
74LS109	.40	74LS364	1 95
74LS112	.45	74LS365	95
74LS113	.48	74LS366	95
74LS114	50	74LS367	70
74LS122	45	74LS368	70
74LS123	95	74LS373	1.85
74LS124	2.99	74LS374	1.80
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74LS132	75	74LS379	1 35
74LS136	.55	74LS385	1 90
74LS137	99	74LS386	65
74LS138	.75	74LS390	1.90
74LS139	.78	74LS393	1 90
74LS145	1.20	74LS395	1 65
74LS147	2.49	74LS399	1 70
74LS148	1.35	74LS447	.37
74LS151	75	74LS490	1 95
74LS153	75	74LS668	1.69
74LS154	2 35	74LS669	1 89
74LS155	1 15	74LS670	2.20
74LS156	.95	74LS674	9 65
74LS157	75	74LS682	3 20
74LS158	75	74LS683	2.30
74LS160	90	74LS684	2 40
74LS161	95	74LS685	2 40
74LS162	.95	74LS688	2 40
74LS163	95	74LS689	2 40

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LM311	.64	LM1310	2.90
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LM317K	3.95	MC1350V	1 29
LM318	1.49	MC1358	1 79
LM323K	4.95	LM1414	1.59
LM324	59	LM1458V	.69
LM337K	3.95	LM1488	99
LM339	99	LM1489	.99
LM377	2.29	LM1800	2.99
LM380	1.29	LM1889	2.49
LM386V	1.50	LM3900	.59
LM555V	.39	LM3909V	.98
LM556	69	LM3914	3.95
LM565	99	LM3915	3.95
LM566V	1.49	LM3916	3.95
LM567V	1 29	75451V	.39
LM723	49	75452V	39
LM733	98	75453V	.39

T=TO-220 V=8 PIN K=TO-3

8200

8202	45 00
8205	3.50
8212	1.85
8214	3.90
8216	1.85
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8228	4.95
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8250	14.95
8251	5.50
8253	9.95
8253-5	9 95
8255	5.25
8255-5	5 25
8257	9 00
8259	7.00
8272	39 95
8275	29 95
8279	10 50
8279-5	10 50
8282	6.55
8283	6.55
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8155	11 95
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8185-2	39 95
8741	39 95
8748	69 95
8755	49 95

Z80

Z80	8 95
Z80A	9 95
Z80B	19 95
Z80-PIO	8 50
Z80A-PIO	8 60
Z80-CTC	8 50
Z80A-CTC	8 65
Z80-DART	15 25
Z80A-DART	18 75
Z80-DMA	17 50
Z80A-DMA	27 50
Z80-SIO/0	23 95
Z80A-SIO/0	28 95
Z80-SIO/1	23 95
Z80A-SIO/1	28 95
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6802	11.95
6809	37 95
6810	4 00
6820	4.95
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6828	9.95
6834	16.95
6840	14.95
6843	42 95
6844	44.95
6845	29.95
6847	15 95
6850	4 75
6852	5 75
6860	10.95
6862	11.95
6871	25 95
6875	6.95
6880	2 95

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MC1330	1 89
MC1350	1 29
MC1358	1.79
LM380	1 29
LM386	1 50
LM565	99
LM741	.29
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LM1800	2 99
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2758	1024 x 8	(450ns)(5v)	9 95	8 95
TMS2516	2048 x 8	(450ns)(5v)	7 95	6.95
2716	2048 x 8	(450ns)(5v)	5 95	5.50
2716-1	2048 x 8	(350ns)(5v)	12 95	11.95
TMS2716	2048 x 8	(450ns)	9 95	8.95
TMS2532	4096 x 8	(450ns)(5v)	19 95	17.95
2732	4096 x 8	(450ns)(5v)	16 50	15 95

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2112	256 x 4	(450ns)	2.99	2 79
2114	1024 x 4	(450ns)	8/17.95	2 10
2114L-2	1024 x 4	(200ns)(LP)	8/22.95	2 45
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2114L-4	1024 x 4	(450ns)(LP)	8/18 95	2 25
TMS4044-4	4096 x 1	(450ns)	3 49	3 25
TMS4044-3	4096 x 1	(300ns)	3 99	3 75
TMM2016	2048 x 8	(200ns)	CALL	
HM6116	2048 x 8	(200ns)	CALL	

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7815T	.99	7924T	1 19
7824T	.99		
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1 49
7815K	1.39	79L05	79
78L05	.69	79L12	79
78L12	69	79L15	79
78L15	.69	LM317K	3.95
LM309K	1.49	LM323K	4.95
LM317T	1 95	LM337K	3.95

T=TO-220 K=TO-3 L=TO-92

IC SOCKETS

	1-100	100p
8 pin ST	.13	
14 pin ST	15	
16 pin ST	17	
18 pin ST	.20	
20 pin ST	.29	
22 pin ST	30	
24 pin ST	.30	
28 pin ST	.40	
40 pin ST	49	

ST = SOLDERTAIL

8 pin WW	.59	
14 pin WW	69	
16 pin WW	.69	
18 pin WW	99	
20 pin WW	1.09	
22 pin WW	1 39	1
24 pin WW	1 49	1
28 pin WW	1.69	1
40 pin WW	1 99	1

WW = WIREWRAP

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74C04	.35	74C902	.85	4021	.95	14409	8.95
74C08	.35	74C903	.85	4022	1.15	14410	8.95
74C10	.35	74C905	10.95	4023	.35	14411	9.95
74C14	1.50	74C906	.95	4024	.75	14412	12.95
74C20	.35	74C907	1.00	4025	.35	14419	2.95
74C30	.35	74C908	2.00	4026	1.65	4502	.95
74C32	.50	74C909	2.75	4027	.65	4503	.65
74C42	1.75	74C910	9.95	4028	.80	4508	1.95
74C48	2.10	74C911	10.00	4029	.95	4510	.95
74C73	.65	74C912	10.00	4030	.45	4511	.95
74C74	.85	74C914	1.95	4034	2.95	4512	.95
74C76	.80	74C915	2.00	4035	.85	4514	1.25
74C83	1.95	74C918	2.75	4040	.95	4515	2.25
74C85	1.95	74C920	17.95	4041	1.25	4516	1.55
74C86	.95	74C921	15.95	4042	.75	4518	1.25
74C89	4.50	74C922	5.95	4043	.85	4519	1.25
74C90	1.75	74C923	5.95	4044	.85	4520	1.25
74C93	1.75	74C925	6.75	4046	.95	4522	1.25
74C95	1.75	74C926	7.95	4047	.95	4526	1.25
74C107	1.00	74C927	7.95	4049	.55	4527	1.95
74C150	5.75	74C928	7.95	4050	.55	4528	1.25
74C151	2.25	74C929	19.95	4051	.95	4531	.95
74C154	3.25	74C930	19.95	4053	.95	4532	1.95
74C157	1.75	4000	.35	4060	1.45	4538	1.95
74C160	2.00	4001	.35	4066	.75	4539	1.95
74C161	2.00	4002	.25	4068	.40	4543	2.70
74C162	2.00	4006	.95	4069	.35	4555	.95
74C163	2.00	4007	.29	4070	.35	4556	.95
74C164	2.00	4008	.95	4071	.30	4581	1.95
74C165	2.00	4009	.45	4072	.30	4582	1.95
74C173	2.00	4010	.45	4073	.30	4584	.95
74C174	2.25	4011	.35	4075	.30	4585	.95
74C175	2.25	4012	.25	4076	.95	4702	12.95
74C192	2.25	4013	.45	4078	.30	4724	1.50
74C193	2.25	4014	.95	4081	.30	80C07	.95
74C195	2.25	4015	.95	4082	.30	80C95	.85
74C200	5.75	4016	.45	4085	.95	80C96	.95
74C221	2.25	4017	1.15	4086	.95	80C97	.95
74C373	2.75	4018	.95	4093	.95	80C98	1.20

74S00 SERIES

74S00	.44	74S74	.69	74S163	3.75	74S258	1.49
74S02	.48	74S85	2.39	74S168	4.65	74S260	1.63
74S03	.48	74S86	1.44	74S169	5.44	74S274	19.95
74S04	.79	74S112	1.59	74S174	1.09	74S275	19.95
74S05	.79	74S113	1.98	74S175	1.09	74S280	2.90
74S08	.48	74S114	1.50	74S181	4.47	74S287	4.75
74S09	.98	74S124	2.77	74S182	2.95	74S288	4.45
74S10	.69	74S132	1.24	74S188	3.95	74S289	6.98
74S11	.88	74S133	.98	74S189	14.95	74S301	6.95
74S15	.70	74S134	.69	74S194	2.95	74S373	3.45
74S20	.68	74S135	1.48	74S195	1.89	74S374	3.45
74S22	.98	74S138	1.08	74S196	4.90	74S381	7.95
74S30	.48	74S139	1.25	74S197	4.25	74S387	5.75
74S32	.98	74S140	1.45	74S201	14.95	74S412	2.98
74S37	1.87	74S151	1.19	74S225	8.95	74S471	9.95
74S38	1.68	74S153	1.19	74S240	3.98	74S472	16.85
74S40	.44	74S157	1.19	74S241	3.75	74S474	17.85
74S51	.78	74S158	1.45	74S251	1.90	74S482	15.60
74S64	.79	74S161	2.85	74S253	7.45	74S570	7.80
74S65	1.25	74S162	3.70	74S257	1.39	74S571	7.80

PROMS

74S188	(82S23)	OC	32 x 8	3.95
74S287	(82S129)	TS	256 x 4	4.75
74S288	(82S123)	TS	32 x 8	4.45
74S387	(82S126)	OC	256 x 4	5.75
74S471		TS	256 x 8	9.95
74S472	(82S147)	TS	512 x 8	16.85
74S474	(82S141)	TS	512 x 8	17.85
74S570	(82S130)	OC	512 x 4	7.80
74S571	(82S131)	TS	512 x 4	7.80

7400 SERIES

7400	.19	74128	.55
7401	.19	74132	.45
7402	.19	74136	.50
7403	.19	74141	.65
7404	.19	74142	2.95
7405	.22	74143	2.95
7406	.22	74144	2.95
7407	.22	74145	.60
7408	.24	74147	1.75
7409	.19	74148	1.20
7410	.19	74150	1.35
7411	.25	74151	.65
7412	.30	74152	.65
7413	.35	74153	.55
7414	.55	74154	1.40
7416	.25	74155	.75
7417	.25	74156	.65
7420	.19	74157	.55
7421	.35	74159	1.65
7422	.29	74160	.85
7423	.29	74161	.70
7425	.29	74162	.85
7426	.29	74163	.85
7427	.29	74164	.85
7428	.45	74165	.85
7430	.19	74166	1.00
7432	.29	74167	1.95
7433	.45	74170	1.65
7437	.29	74172	5.95
7438	.29	74173	.75
7440	.19	74174	.89
7442	.49	74175	.89
7443	.65	74176	.89
7444	.69	74177	.75
7445	.69	74178	1.15
7446	.59	74179	1.75
7447	.69	74180	.75
7448	.69	74181	2.25
7450	.19	74182	.75
7451	.23	74184	2.00
7453	.23	74185	2.00
7454	.23	74186	18.50
7460	.23	74190	1.15
7464	.39	74191	1.15
7465	.39	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.35	74196	.79
7475	.49	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7484	.90	74248	1.85
7485	.65	74249	1.95
7486	.35	74251	.75
7489	4.95	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.49	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.00	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.55	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
		74490	2.55

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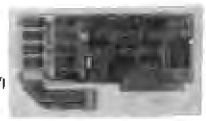
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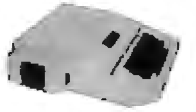


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74LS02	.25	74LS125	.90	74LS261	2.45
74LS03	.25	74LS126	.80	74LS266	.50
74LS04	.25	74LS132	.75	74LS273	1.60
74LS05	.25	74LS136	.50	74LS275	3.30
74LS08	.30	74LS138	.75	74LS279	.50
74LS09	.25	74LS139	.75	74LS280	1.95
74LS10	.25	74LS145	1.10	74LS283	.95
74LS11	.30	74LS147	2.25	74LS290	1.20
74LS12	.30	74LS148	1.25	74LS293	1.80
74LS13	.40	74LS151	.75	74LS295	1.00
74LS14	.75	74LS153	.75	74LS298	.95
74LS15	.30	74LS155	.90	74LS299	2.50
74LS20	.25	74LS156	.90	74LS323	3.95
74LS21	.30	74LS157	.75	74LS324	1.75
74LS22	.25	74LS158	.75	74LS347	1.95
74LS26	.30	74LS160	.90	74LS348	1.95
74LS27	.35	74LS161	.90	74LS352	1.50
74LS28	.35	74LS162	.90	74LS353	1.50
74LS30	.25	74LS163	.80	74LS363	1.35
74LS32	.35	74LS164	.90	74LS365	.90
74LS33	.55	74LS165	.90	74LS366	.90
74LS37	.50	74LS166	2.00	74LS367	.65
74LS38	.35	74LS168	1.70	74LS368	.65
74LS40	.25	74LS169	1.70	74LS373	1.15
74LS42	.50	74LS170	1.70	74LS374	1.75
74LS47	.75	74LS173	.75	74LS375	.65
74LS48	.75	74LS174	.90	74LS377	1.40
74LS49	.75	74LS175	.90	74LS385	1.95
74LS51	.25	74LS181	2.10	74LS386	.60
74LS54	.35	74LS189	8.95	74LS390	1.85
74LS55	.35	74LS190	.95	74LS393	1.85
74LS63	1.20	74LS191	.95	74LS395	1.80
74LS73	.35	74LS192	.80	74LS399	1.65
74LS74	.40	74LS193	.90	74LS424	2.95
74LS75	.50	74LS194	.95	74LS447	.35
74LS76	.40	74LS195	.90	74LS490	1.90
74LS78	.50	74LS196	.80	74LS630	75.00
74LS83	.75	74LS197	.80	74LS640	3.00
74LS85	1.10	74LS221	1.15	74LS641	3.00
74LS86	.40	74LS240	1.15	74LS642	3.00
74LS90	.60	74LS241	1.15	74LS645	3.00
74LS91	.80	74LS242	1.65	74LS668	1.65
74LS92	.65	74LS243	1.65	74LS669	1.65
74LS93	.60	74LS244	1.00	74LS670	2.15
74LS95	.80	74LS245	1.95	74LS674	9.60
74LS96	.80	74LS247	.75	74LS682	3.15
74LS107	.40	74LS248	1.20	74LS683	2.25
74LS109	.40	74LS249	.95	74LS684	2.35
74LS112	.40	74LS251	1.25	74LS685	2.35
74LS113	.40	74LS253	.80	74LS688	2.35
74LS114	.50	74LS257	.80	74LS689	2.35
74LS122	.45	74LS258	.80		

74S00

74S00	.40	74S163	3.70
74S02	.45	74S168	4.60
74S03	.45	74S169	5.40
74S04	.75	74S174	1.05
74S05	.75	74S175	1.05
74S08	.45	74S181	4.45
74S09	.75	74S182	2.90
74S10	.65	74S188	3.90
74S11	.80	74S189	14.90
74S15	.65	74S194	2.90
74S20	.65	74S195	1.85
74S22	.75	74S196	4.85
74S30	.45	74S197	4.20
74S32	.95	74S201	14.90
74S37	1.85	74S225	8.90
74S38	1.85	74S240	3.95
74S40	.40	74S241	3.70
74S51	.75	74S251	1.85
74S64	.75	74S253	7.40
74S65	1.20	74S257	1.35
74S74	.65	74S258	1.45
74S85	2.35	74S260	1.80
74S86	1.40	74S274	19.90
74S112	1.55	74S275	19.90
74S113	1.95	74S280	2.85
74S114	1.45	74S287	4.70
74S124	2.75	74S288	4.40
74S132	1.20	74S289	6.95
74S133	.95	74S301	6.90
74S134	.65	74S373	3.40
74S135	1.45	74S374	3.40
74S138	1.05	74S381	7.90
74S139	1.20	74S387	5.70
74S140	1.40	74S412	2.95
74S151	1.15	74S471	9.90
74S153	1.15	74S472	16.80
74S157	1.15	74S474	17.80
74S158	1.40	74S482	15.50
74S161	2.80	74S570	7.75
74S162	3.70	74S572	7.75

74C00 CMOS

74C00	.35	74C195	2.20
74C02	.35	74C221	2.20
74C04	.35	74C240	2.20
74C08	.35	74C244	2.20
74C10	.35	74C373	2.70
74C14	1.45	74C374	2.70
74C20	.35	74C901	.80
74C30	.35	74C902	.80
74C32	.50	74C903	.80
74C42	1.70	74C904	.80
74C48	2.05	74C905	10.90
74C73	.85	74C906	.90
74C74	.85	74C907	.90
74C76	1.90	74C908	2.00
74C83	1.90	74C909	2.70
74C86	.90	74C910	9.90
74C89	4.50	74C911	9.90
74C90	1.70	74C912	9.90
74C93	1.70	74C914	1.90
74C95	1.70	74C915	1.90
74C107	.85	74C917	2.70
74C150	5.70	74C918	1.90
74C151	2.20	74C920	18.00
74C154	3.20	74C922	5.90
74C157	1.75	74C923	5.90
74C160	1.95	74C925	6.70
74C161	1.95	74C926	7.90
74C162	1.95	74C927	7.90
74C163	1.95	74C928	7.90
74C164	1.95	74C929	7.90
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74C174	2.20	74C941	2.75
74C175	2.20	74C989	9.90
74C192	2.20	80C95	.85
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4006	.95	4043	.85	4505	8.95
4007	.35	4044	.85	4506	1.25
4008	.95	4046	.95	4507	.95
4009	.45	4047	.95	4508	1.95
4010	.45	4048	.75	4510	.95
4011	.35	4049	.55	4511	.95
4012	.35	4050	.55	4512	.95
4013	.45	4051	.95	4514	2.25
4014	.95	4052	.95	4515	2.25
4015	.95	4053	.95	4516	1.50
4016	.45	4055	2.75	4518	1.25
4017	.95	4056	2.75	4519	1.25
4018	.95	4059	9.95	4520	1.25
4019	.45	4060	1.25	4522	1.25
4020	.95	4066	.75	4526	1.25
4021	.95	4068	.40	4527	1.75
4022	.95	4069	.40	4528	1.25
4023	.35	4070	.40	4531	.95
4024	.75	4071	.30	4532	1.75
4025	.35	4072	.30	4539	1.75
4026	1.95	4073	.30	4543	1.95
4027	.65	4075	.30	4553	4.95
4028	.80	4076	.95	4555	.95
4029	.95	4078	.50	4556	.95
4030	.45	4081	.40	4558	2.25
4031	1.50	4082	.40	4568	5.95
4032	2.75	4085	.95	4581	1.95
4033	2.75	4086	.95	4582	1.95
4034	2.75	4093	.95	4584	.95
4035	.85	4094	3.95	4585	.95
4037	2.50	4099	1.75	4702	9.95

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7905K	1.50			LM3915	3.75
7912K	1.50	LM555V	.40	LM3916	3.75
79L05	.75	LM556	.70	DS75451	.40
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FOR SALE: Complete system: IMSAI 8080 computer with 64 K memory, Lear-Siegler ADM-3 terminal, and Altair disk drive. Good condition. Best offer on all three. Jim Fritz, 1413 Harmony Ln, Annapolis MD 21401, (301) 757-7019

WANTED: Complete documentation for Digital Systems DSC-2 microprocessor and disk, Texas Instruments TI-810 printer, and ADM-3A terminal. All missing when purchased at auction. Also, need information on adding lowercase to printer and display. Please state price in letter. N C Helmkay, POB 446, Milliken Ontario, L0H 1K0 Canada, (416) 297-4337 after 6 PM ET

FOR SALE: Complete Space Invaders board set, including power-supply board (the arcade version). An 8080A-based computer with high-resolution composite video output and extensive sound-synthesizing capability. No read-only memories—needs 2716, 2708, or equivalent. Full schematic included, program listing available. $150. Send check or SASE for more information. Rom Mahboubi, 910 S Orange Ave, Short Hills NJ 07078

FOR SALE: IBM 3275 Model 2 display terminal with keyboard and documentation. Excellent condition. $1200. B Pelkey, (305) 862-0875

FOR SALE: ASR33 Teletype with paper-tape reader/punch, modem, touch-tone telephone pad, and stand; $425. Altair 8800A computer with S-100 bus, 24 K programmable memory, and serial/parallel I/O, $550. Heathkit IM-16 voltmeter, $18. TRW MPY-16 high-speed 16- by 16-bit multiplier chip, $40. Lenny Heath, 6618-D Lake Hill Dr, Raleigh NC 27609, (919) 876-4168

FOR SALE: Heath H-14 printer. Like new. $400 plus shipping. Dr Walt Alfons, Qtrs 4410A, USAF Academy CO 80840, (303) 472 1362

FOR SALE: 32 K TRS-80 Model I with TRS-80 disk drive and TRSDOS. Includes all manuals, cassette player, all cables, and TRS-80 Editor/Assembler. Other software includes Space Invaders and other games. $1800. Robert Topping, 17 Cognac Dr, Lake Saint Louis MO 63367

FOR SALE: Brand-new SD Systems SBC-200 single-board computer and SD Systems Versafloppy II disk controller. Assembled and tested by SD Systems. Total kit price is $840. Will sell for $600 if purchased together. James Adams, 6405 Maryland Ave, Hammond IN 46323, (219) 844-4691. No collect calls accepted

FOR SALE: New original package LOBOS 8-inch dual-drive cabinet plus power supply, Technico TI9900, 16-bit processor system, 64 K programmable memory, disk-controller board, DOS 3.0 Super BASIC plus EAL. Perfect operating condition. Full documentation and schematics. $3500 or best offer. Sam White, 643 Indiana Ave, Venice CA 90291 (213) 549-2500 or 396-0936

FOR SALE: BYTE #1 thru August 1979, 48 issues: $100 or best offer. Extra BYTEs #1 thru #4, best offer. Kilobaud Microcomputing #1 thru August 1978, 20 issues; $50 or best offer. Extra Kilobaud Microcomputing #1 thru #5 best offer. HP-524D counter, 525C 100 thru 500 MHz, 525A 10 thru 100 MHz, 526A video amplifier, 526C period multiplier, plug-ins, manuals, used as laboratory standard, best reasonable offer. Sandy Frazier, 5325 Curry Ford Rd #A203 Orlando FL 32806

WANTED: A source of programs on Tarbell cassettes. I've just bought a Tarbell interface board to act as archival storage, and want to correspond with a Tarbell users group or an individual with programs to sell or trade. Has anybody interfaced the Tarbell board to the Megatape system, ALPHA-1, using the S-100 bus? I would like to hear from you. Duane L Erwin, 335 S Wabash, Bradley IL 60915, (815) 933-7566 days

WANTED: Computer Music Journal back issues: volume 1, numbers 1, 2, and 4. John Valente, Box 9, Marlboro VT 05344

WANTED: Used Apple II disk drive (DOS 3.3) with controller card. Give price and all pertinent details. Michael Levin, 18 Peacock Farm Rd, Lexington MA 02173, (617) 862-5134 collect

FOR SALE: Model ASR33 teletypewriter. Extra ribbons and paper. Manuals and schematics. $450. Will deliver within 200 miles of Alamogordo. David L Marshall, 1803 Scenic Dr, Alamogordo NM 88310, (505) 437-6374

WANTED: A Digital Group Systems digital cassette drive (Phi-Deck). It should be in good condition with the original connectors, and in the range of $50 to $100. Send name, phone, hours you can be reached, and price. Brad Manske, 1315 W 5th, North Platte NE 69101

FOR SALE: Heath-89 48 K programmable memory, serial interface board, one floppy, HDOS plus Heath BASIC and assembly-language programming courses, and extras. $1900. John Guerriero, 172 Ludlam Ave, Elmont NY 11003 (516) 354-1797.

FOR SALE: KIM-1 microcomputer with manuals and power supply, $125. KIM 6502 software (books, games, applications), $20. 77-key ASCII-encoded, word-processing keyboard. Excellent condition, documentation included; $45. Mark Beall, 2505 Manorwood Dr, Puyallup WA 98371

FOR SALE: Word processor/text editor for North Star. Includes utility programs with documentation on disk. Needs only 24 K BASIC and one disk. Easy-to-use line-oriented editor works with any ASCII terminal, including Teletype or CRT. Word processor allows commands in the file, and chaining to other text files, like subroutines in a program. $30. Mark Arnold, 1400 Grand Ave, Laramie WY 82070

FOR SALE: Commodore PET 2001 computer. Original 8 K version with video buffer and twelve program tapes, including Microchess 2.0. $500. Floyd Wilson, 903 W Sweet Ave, Bismarck ND 58501 (701) 258-9023

FOR SALE: MicroAce ZX80 2 K (like Sinclair) with manual (Sinclair manual too) and power pack in original box. Works good. Fantastic for the beginner learning BASIC or the experienced Z80 machine-language programmer. First money order for $129 takes it. M Nedich, 18 Hillside Ln N, Syosset NY 11791 (516) 921-3603

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Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: Integer firmware card for Apple II plus. Includes Programmer's Aid No. 1, $100. Fred M Gentile, 10182 Valley Forge Dr, Huntington Beach CA 92646, (714) 962 8447

FOR SALE: AJ 841 terminal IBM 2741 equivalent with acoustic coupler. Like new. Recently factory adjusted. 15-inch wide platen. Very high-quality Selectric mechanism. $840. R Dobbs, 1746 Clarkson Rd #G, Richmond VA 23224

SWAP: TRS-80 Model I, Color, or Model III cassette programs. Games, information processing, and machine-language monitor. No business or education. Also, have M3 machine-language utilities and programs. Send cassette with a few of your programs and your needs (500 bps for I and III) and I will return it with the best of mine. Would also like information on your M3 disk experiences. Steve Kolokowsky, 8 Wilson Ct Spring Valley NY 10977

FOR SALE: Heath H-14 printer. Nearly new, calibrated at a Heath center. $490. Neal De Loye, Rte 1, Onalaska WI 54650, (608) 783-7767 evenings.

FOR SALE: Ithaca Intersystems Z80-based S-100 processor board. Socketed, populated (on-board 2708 1 K EPROM included), assembled and tested, $110. S-100 8 K Ithaca Intersystems static-memory board. Uses 2102 chips, fully socketed, 2 K populated: $60. Parallel ASCII keyboard. Assembled and tested, in chassis with power supply. TTL parallel ASCII output with data-valid strobe, $60. Highest bidder takes. Send SASE. Roy Makrucki, 251 Pleasant Ridge Dr, Saline MI 48176, (313) 429-1286

WANTED: Hewlett-Packard HP-97 calculator. H Verhoeven, Box 4636, Mountain View CA 94040

FOR SALE: Quest Super ELF with low-address display option. $85. Glenn Andreas, Rte 1-7600 Hwy D East, Lake Tomahawk WI 54539

FOR SALE: 10 MHz 8086 processor, $60. Intersil IM6100 Family Sampler (PDP-8 with 1 K read-only memory monitor, 256 words programmable memory, serial I/O), $50. Programmable/EPROM memories (eight 4 K by 1 programmable memories, six 2716 and one 2708 EPROMs), $75. IC grab bag (forty-five 7400 series digital, ten op amps, voltage regulators, seven segment LEDs); $15. Gregg Marshall, 967 Almond Dr, Oakley CA 94598.

FOR SALE: VDB-8024 video board. S-100, assembled and tested, 80 columns by 24 lines. Video enhancements include scroll, tab, reverse, blinking, and underline. Protect feature. 32 special characters, including Greek and math symbols. Addressable cursor. Very fast. Complete documentation included. Still under warranty. $275 plus COD. Tom Kirby, 318 W Clay, Blacksburg VA 24060

FOR SALE: Alpha Micro computer system. AM100 64 K processor, SOROC IQ 120 terminal, AM200 floppy-disk controller board, AM300 6 port serial I/O mux. Wangco/Orbis 87 dual-disk drive, TI-810 serial printer. Business software available. Best offer. Ron Bogaards, 108 Peace St, Pella IA 50219 (515) 628-9295

FOR SALE: SwTPC 68/2, two serial, one parallel, 20 K programmable memory, 4 K EPROM, EPROM programmer and eraser, JPC cassette interface and recorder, CFM, two memory-mapped video boards, lots of software, and twenty cassettes in excellent condition with complete documentation for $600. Also, AC-30, $75. Send SASE for more details. Joe Williams, 2780 Janitell Rd, Colorado Springs CO 80906 (303) 599-4828 or 473-8060 evenings

FOR SALE: S-100 boards: TDL Z80 ZPU, SMB1, SMB2, parallel I/O (4 ports), four 16 K programmable memories, Jade Z80 4 MHz, $50 each. KIM-1 system: 40 K, ASCII keyboard, TV interface, power supply, software, and BASIC, $160. Jade two 8-inch dual-disk/double-density controller drives, PROM boot, CP/M 2.2, cabinet, power supply, cables, manuals, system disks, and utilities. For S-100. Used approximately two hours. Cost $1400. Sell $700. Send money order or cashier's check and phone number (confirmation of sale). Brian Graves, Abbot Hill Rd, Wilton NH 03086

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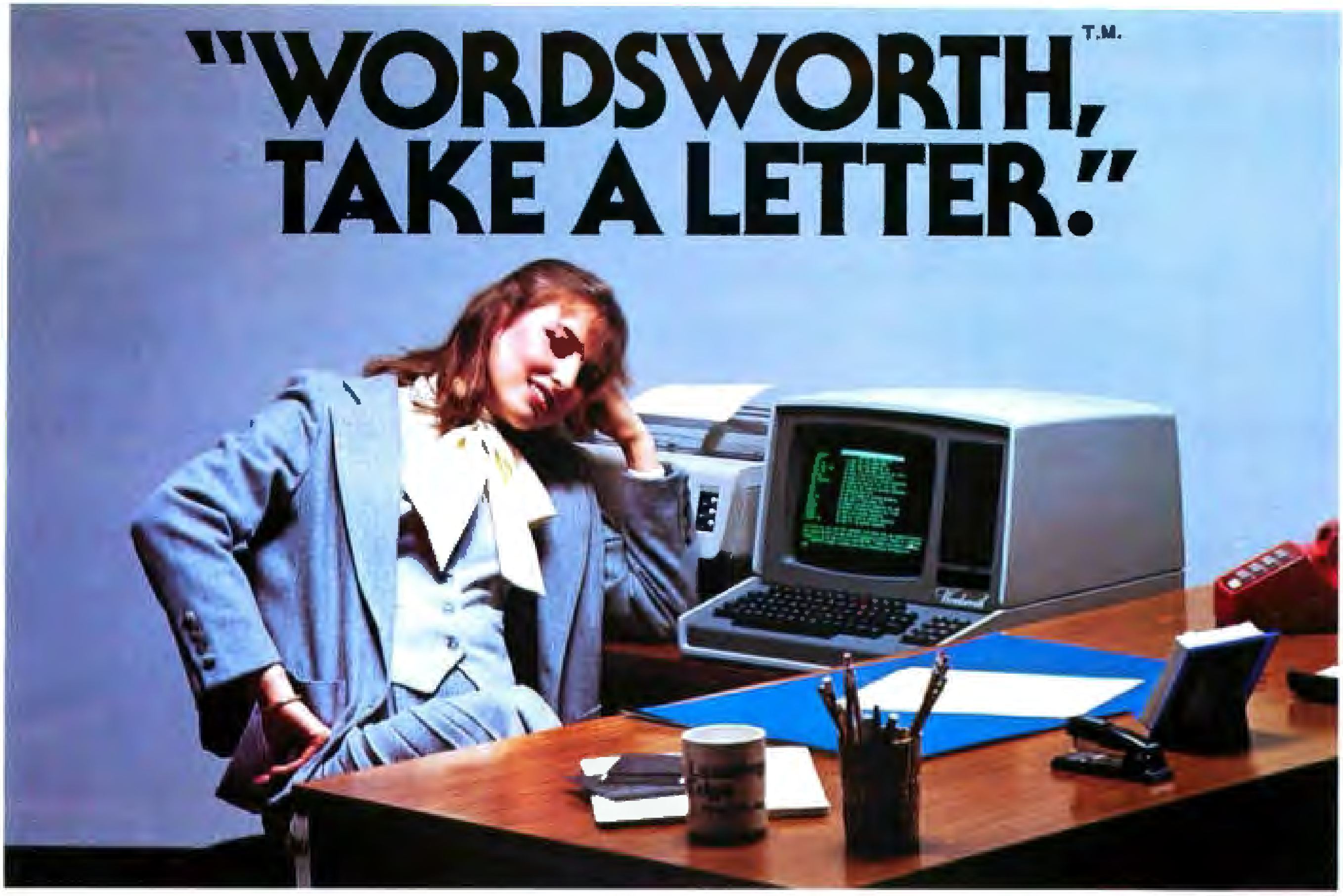
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July Bomb Results: Ciarcia and the Sun

It came as no surprise to us that Steve Ciarcia's article, "Build a Z8-Based Control Computer with BASIC, Part 1," finished first in the July BOMB competition. Steve's latest technological breakthrough has prompted numerous comments and inquiries, both to him and to BYTE. He will receive the $100 first prize.

Second place for July went to George E Mobus for his article, "Harvesting the Sun's Energy." George will receive $50 for his description of a computer model that determines the amount of solar energy received by a flatplate collector.

"Multiprocessing with Motorola's MC6809E," by Hunter Scales, took third place. He showed how to implement a multiprocessor environment using the new MC6809E.



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